WHOI-2012-07

# Woods Hole Oceanographic Institution

# At Sea Test 2 Recovery Cruise
# Cruise 206 On Board R/V *Knorr*
# April 10 – 15, 2012
# Woods Hole – Woods Hole, MA

By

Robert A. Weller[1], John Lund[1], Jeff O'Brien[1], John Kemp[1], Ken Kostel[1], Walt Waldorf[4], Chris Holm[4], Craig Risien[4], Michael Matthewson[5], John Trowbridge[1]

June 14, 2012

## Technical Report

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Ocean Observatories Initiative
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**Approved for Distribution:**

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**Abstract**

The R/V *Knorr*, on Cruise 206, carried out the recovery of three moorings for the Coastal and Global Scale Nodes (CGSN) Implementing Organization of the NSF Ocean Observatories Initiative. These three moorings are prototypes of the moorings to be used by CGSN at the Pioneer, Endurance, and Global Arrays. *Knorr* departed from Woods Hole, Massachusetts on April 10, 2012 and steamed south to the location of the mooring deployments on the shelf break. Over five days, April 10-15, *Knorr* surveyed the bottom at the planned mooring sites, recovered the moorings, and carried out preliminary investigations of mechanical and electrical functionality on the recovered moorings and mooring hardware, including observations of biofouling and corrosion. *Knorr* returned to Woods Hole on April 15, 2012.

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# I. Introduction

## A. Background and Purpose

As part of the Ocean Observatories Initiative (OOI), the Coastal and Global Scale Nodes (CGSN) Implementing Organization (IO) will deploy and maintain the Pioneer Array (Figures 1 and 2, Table 1) and four Global Arrays (Figure 3), and the Endurance Array (EA) IO will deploy and maintain lines off Oregon and Washington (Figure 4), as described in the OOI Final Network Design (Reference 1).

At Sea Test 2 (AST2) was undertaken to test prototypes of the Coastal Surface Mooring (CSM) and the Coastal Profiler Mooring (CPM) to be used in the Pioneer and Endurance Arrays (Figures 1 and 4), as well as the Global Hybrid Profiler Mooring (GHPM) to be used in the Global Arrays (Figure 3). The AST2 deployment occurred on R/V Oceanus Cruise 475 from September 22-26, 2011 (Reference 2), and the recovery occurred on R/V Knorr Cruise 206 from April 10-15, 2012. The location was near the future site of the Pioneer Array (Table 2).

The present report describes those elements of the AST2 recovery cruise related to the CPM and CSM. Reference 2 describes the AST2 deployment. Reference 3 describes the recovery of the GHPM.

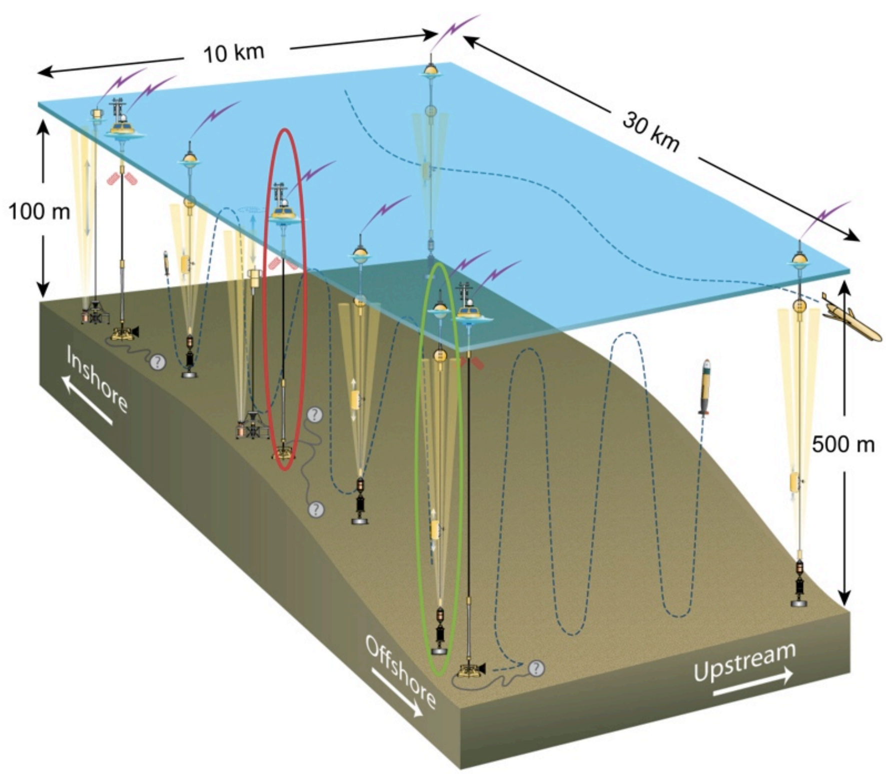

Figure 1: Schematic of the Pioneer Array, to be deployed in the Mid-Atlantic Bight, as described in Reference 1. A Coastal Surface Mooring (CSM) is circled in red, and a Coastal Profiler Mooring (CPM) is circled in green.

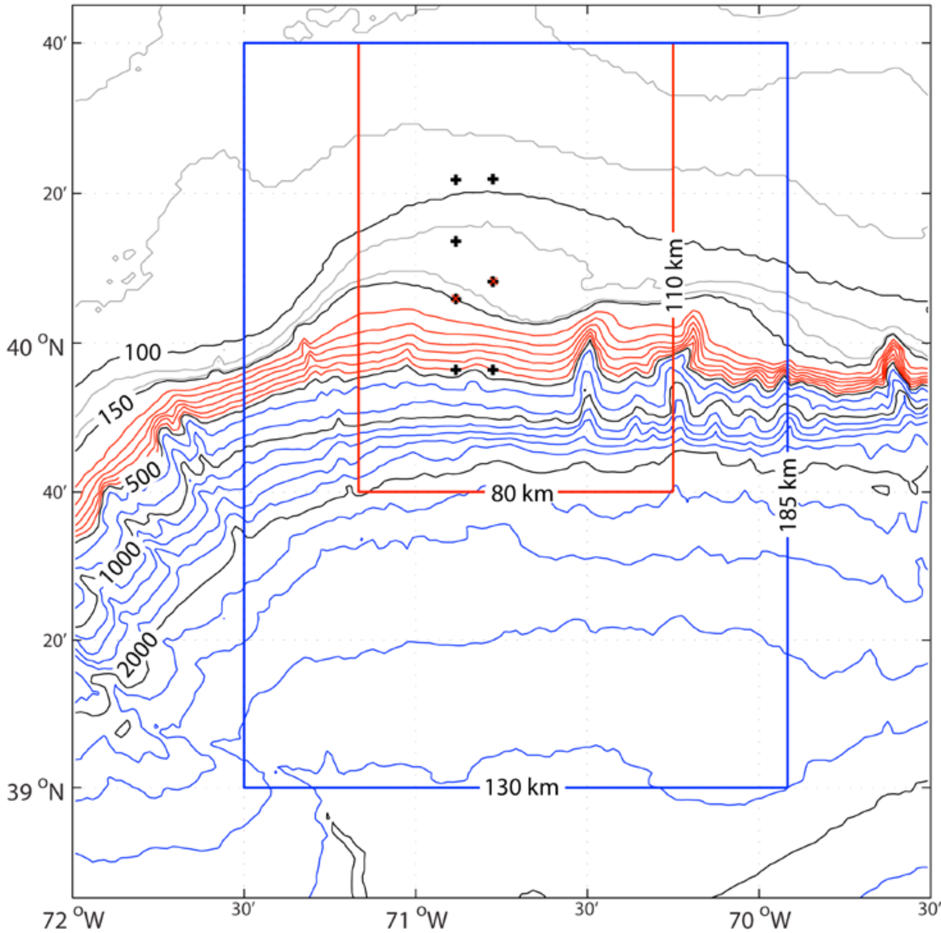


Figure 2: Pioneer Array configuration including mooring sites (+), "hangs" avoided by fishermen (x), the Autonomous Underwater Vehicle (AUV) operations box (red rectangle) and the glider operations box (blue rectangle). Depths are in meters. This configuration, proposed in Engineering Change Request 1303-00443 and summarized in Reference 4, differs from that described in Reference 1 and shown in Figure 1.

Table 1: Locations and depths of mooring sites in Pioneer Array (from Reference 2)

| Site | Center Latitude | Center Longitude | Water Depth (m) |
|---|---|---|---|
| Inshore | 40° 21.8′ N | 70° 53.0′ W | 91.5 |
| Central Inshore | 40° 13.6′ N | 70° 53.0′ W | 125 |
| Central | 40° 08.2′ N | 70° 46.5′ W | 133 |
| Central Offshore | 40° 05.9′ N | 70° 53.0′ W | 150 |
| Offshore | 39° 56.4′ N | 70° 53.0′ W | 450 |
| Upstream Inshore | 40° 21.9′ N | 70° 46.5′ W | 91.5 |
| Upstream Offshore | 39° 56.4′ N | 70° 46.5′ W | 450 |

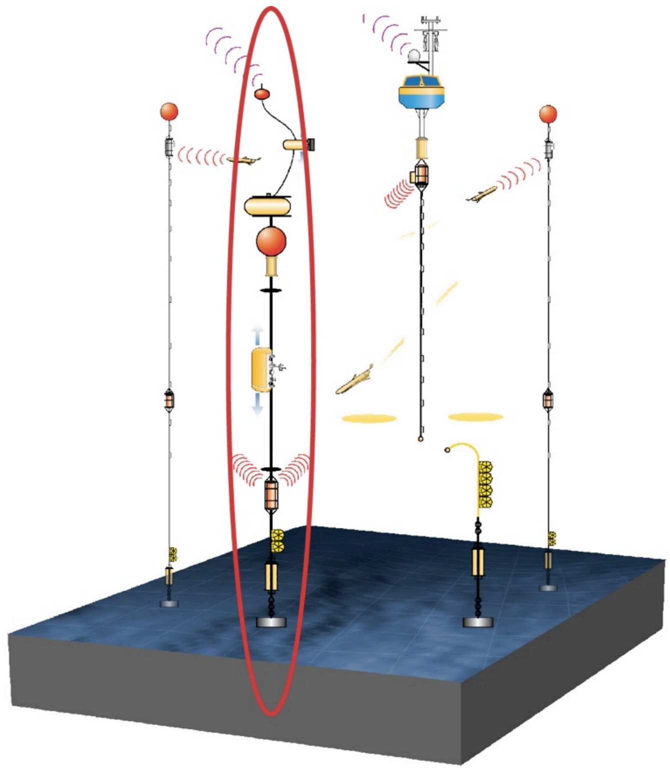

Figure 3: Schematic of a Global Array. CGSN will deploy Global Arrays at sites in the Irminger Sea, 55 South off Chile, the Argentine Basin, and the North Pacific. The Global Hybrid Profiler Mooring (GHPM) is circled in red. The other moorings are two Mesoscale Flanking Moorings (MFMs) and a Global Surface Mooring (GSM).

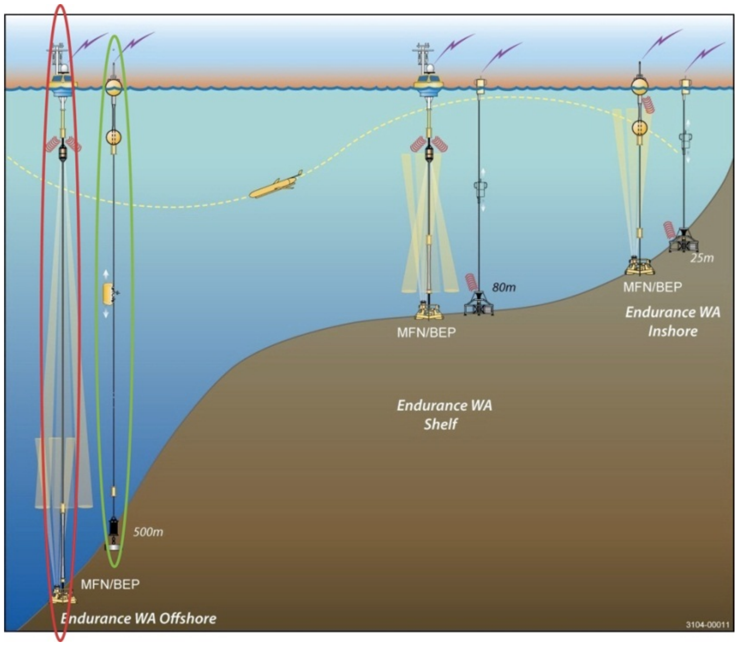


Figure 4: Schematic of the Washington Line of the Endurance Array. A Coastal Surface Mooring (CSM) is circled in red, and a Coastal Profiling Mooring (CPM) is circled in green.

Table 2: Mooring locations and water depths in AST2

| Mooring | Latitude | Longitude | Water depth (m) |
|---|---|---|---|
| CPM | 39º54.681'N | 70º47.853'W | 520 |
| CSM | 39º54.500'N | 70º45.154'W | 520 |
| GHPM | 39º28.782'N | 70º48.840'W | 2480 |

The goals of AST2, as summarized in the At-Sea Test 2 Development Test (DT) Plan (Reference 5), are (1) characterization of Electro Mechanical (EM) hose and cable operation and durability at sea, including assessment of communications links between the surface buoy and subsurface instruments and EM stretch hose aging and response under typical at-sea conditions; (2) assessment of power generation/availability for the rechargeable power supply, including measuring wind generator power production under a range of conditions and characterization of the durability of these components at sea and measurement of solar power production in the field; (3) assessment of power consumption of primary power supplies of sensors and profilers under at-sea conditions; (4) documentation of platform controller functionality, telemetry functions, and data acquisition software, including tests of the platform controller and its associated software and telemetry functions in the field, tests of the telemetry system operation, durability, and power consumption, tests of the instrument interfaces, data acquisition hardware and software, and of exemplar instruments in the field, and assessment of connection durability for inductive telemetry links; (5) assessment of the effects of biofouling on sensor performance, including on profiler power consumption and profiler performance; (6) validation of procedures for deployment and recovery of the CGSN moorings; (7) test of the initial implementations of the Operations and Maintenance Center OMC software specific to basic health and status monitoring and control operations; (8) validation of mooring design analysis assumptions and performance through post-recovery data assimilation; and (9) validation of active radar target enhancer power consumption and visibility. A tenth goal, added prior to the AST2 recovery, is acquisition of high-resolution bathymetry at selected locations within the future site of the Pioneer Array.

## B. Cruise Track, Chronology, and Conditions

The cruise track (Figures 5 and 6) and chronology (Table 3) describe *Knorr's* passage south from Woods Hole to the Pioneer Array area, surveying the bottom with the ship's multi-beam sonar, and her course while recovering the GHPM, CPM, and CSM. The shipboard data (Figure 7) indicates light to moderate winds. Except for some rain on April 12, the days were sunny. Sea states were moderate to calm.

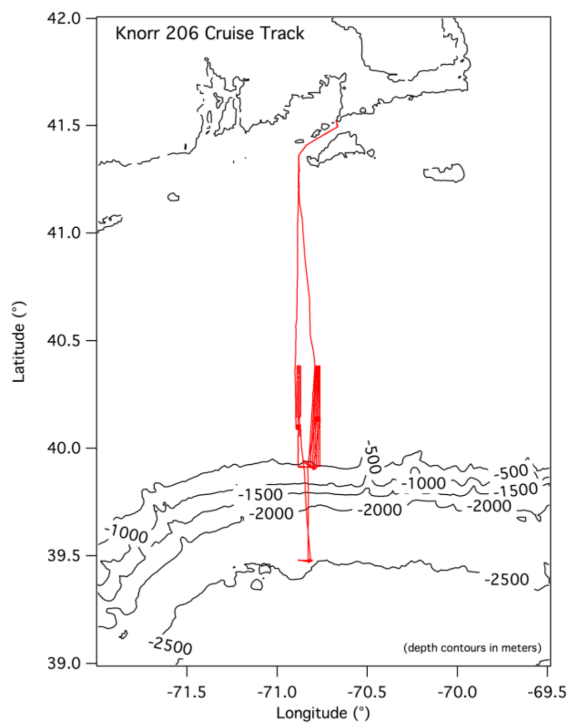

Figure 5: Cruise track.

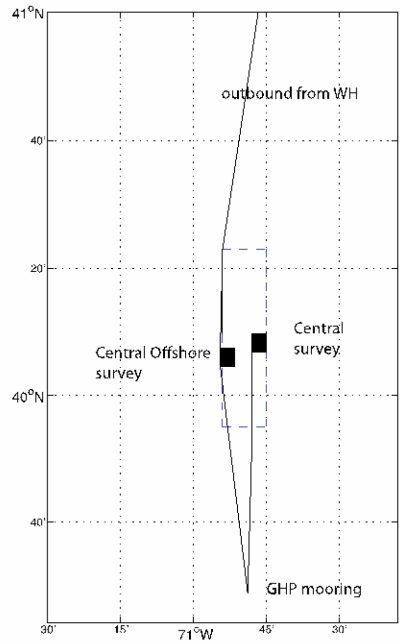


Figure 6: Detail of initial part of cruise track showing sites of GHPM mooring and detailed 2 km by 2 km surveys.

Table 3: Cruise chronology

| Date | Time (EDT) | Activity |
|---|---|---|
| April 10 | 1200 | Depart WHOI. |
| | 2030 | Initiate 2 km by 2 km bathymetric survey of Pioneer Array Central Offshore Site in radiator pattern with east-west lines spaced at 100 m. |
| April 11 | 0230 | End bathymetric survey of Pioneer Array Central Offshore Site. |
| | 0630 | Arrive AST2 GHPM site. |
| | 0630-1600 | Recovery of GHPM (details in Reference 3). |
| | 1600 | Depart AST2 GHPM site. |
| | 2100 | Initiate 2 km by 2 km bathymetric survey of Pioneer Array Central Site in radiator pattern with east-west lines spaced at 100 m. |
| April 12 | 0300 | End bathymetric survey of Pioneer Array Central Site. |
| | 0400 | Arrive AST2 CPM site. |
| | 0400-1800 | Recovery of AST2 CPM (details below). |
| | 1800 | Initiate bathymetric survey along Pioneer Array Main Line; one |

| | | |
|---|---|---|
| | | northward line; one southward line positioned to achieve 30% overlap with northward line. |
| April 13 | 0600 | End bathymetric survey along Pioneer Array Main Line. |
| | 0600-1600 | Recovery of AST2 CSM (details below). |
| | 1600 | Initiate bathymetric survey along Eastern Mooring Line of Pioneer Array with north-south lines stepping westward. |
| April 14 | 2200 | Depart Pioneer Array site. |
| April 15 | 0700 | Arrive WHOI. |

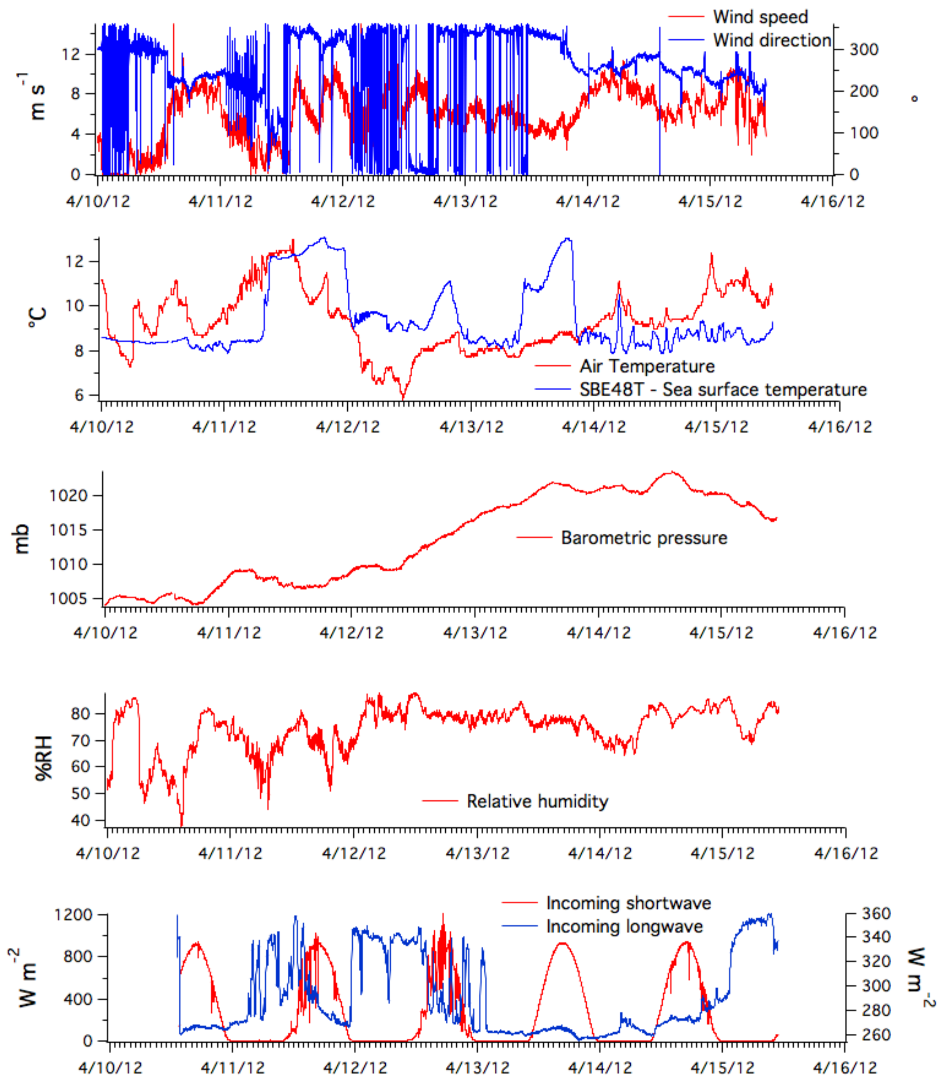


Figure 7: Shipboard data versus time (GMT), including wind speed and direction (top), air and sea temperature, barometric pressure, relative humidity, and radiation.

**C. Coastal Profiler Mooring (CPM) Schematic, Recovery, and Data**

The AST2 CPM (Figure 8) consisted, from bottom to top, of an anchor, chain, an acoustic release, chain, glass balls, chain, wire rope, a fixed frame supporting an Acoustic Doppler Current Profiler (ADCP) and a Conductivity-Temperature-Depth (CTD) sensor, a Wire-Following Profiler (WFP), Electro-Magnetic (EM) chain, a 64-inch submerged sphere, EM stretch hose, and a submersible surface buoy (see References 6 and 7).

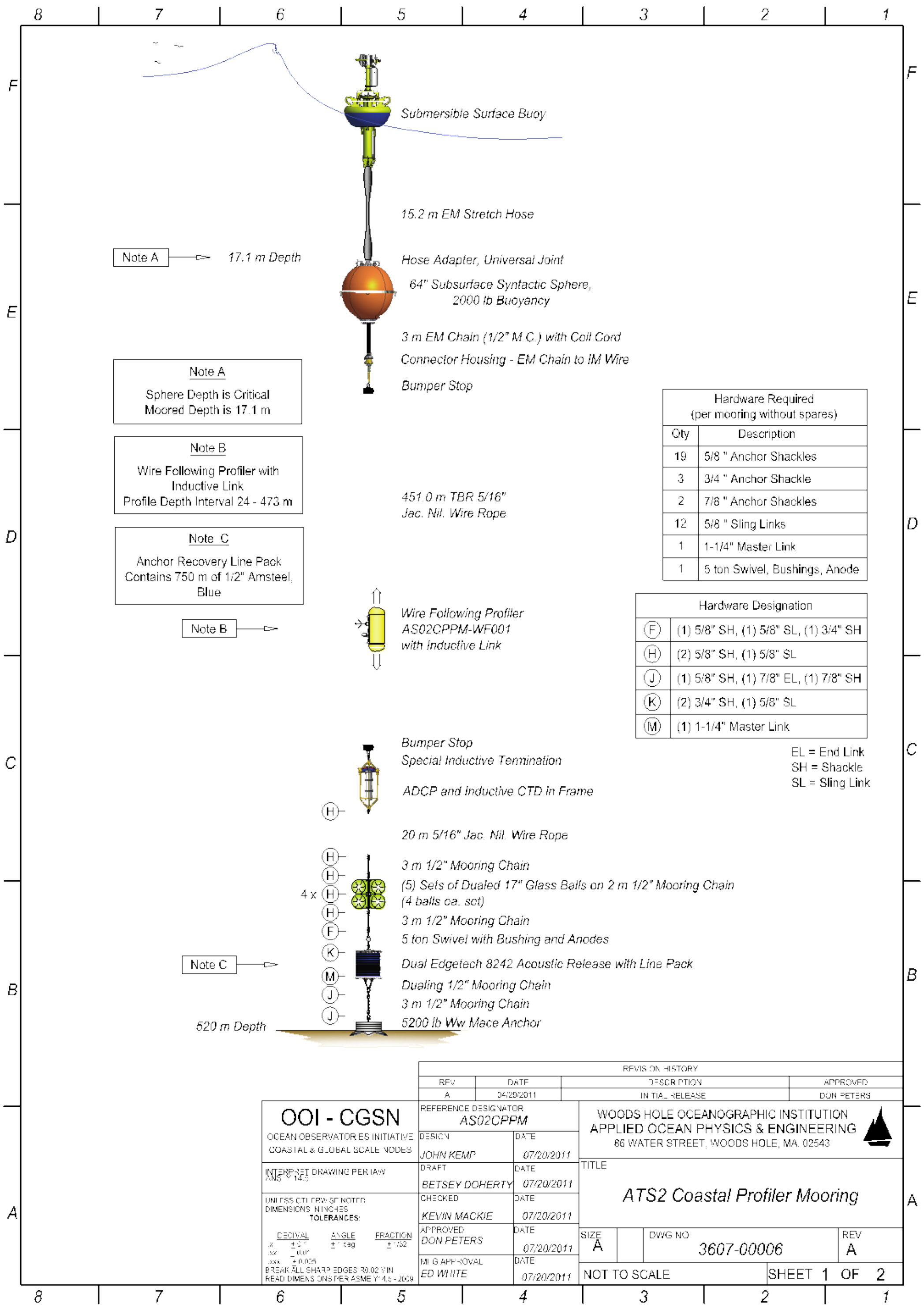


Figure 8: Coastal Profiler Mooring (CPM) as deployed in AST2.

The CPM recovery (Table 3) was as follows. Contact was made with the WFP and the acoustic release. The acoustic release was tripped. Recovery was originally planned to occur bottom-up by first hooking into the glass balls and the accompanying chain. However, the glass balls were dragged beneath the surface by the current. The mooring was instead recovered top-town by starting with the submersible surface buoy. The anchor was recovered last.

Table 3: CPM Recovery Chronology

| Date | Time (EDT) | Activity |
|---|---|---|
| April 11, 2012 | 1245 | To make sure Short Burst Data (SBD) functioning, sent CPM “get_ton”. Response was 1723554, nearly the expected 200 days |
| | 1345 | Sent CPM “set_sbd_iorate 30 15”. |
| | 2000-2300 | Bridge reported radar acquisition. |
| April 12, 2012 | 0400 | Tried to catch the WFP wake but not in range and no signal. |
| | 0416 | Sent “pwron fwwf”. |
| | 0554 | Sent “force_wake”. |
| | 0557 | CPM woke up and logged correctly, showing that the wake was in response to the SBD message. The ship steamed NW away from the buoy because the Freewave antenna was low and aft. The Wifi dropped out at 39 55.2031 N, 70 49.0398 W, roughly 1.05 NM away from the anchor site. The Freewave became unstable at 39 56.1303 N, 70 50.3787 W, roughly 1.38 NM away from the anchor site. |
| | 0600-0800 | CTD to 500 m, position for recovery, rig for recovery. |
| | 0800-1030 | Recovery of CPM, top-to-bottom with buoy first and anchor last. |
| | 1030-1800 | Square away mooring gear and deck. |

Output from the CPM WFP Mission Planner (Figure 9) and selected data (Figure 10) indicate that the system functioned as expected throughout much of the deployment.


Figure 9: Mission Planner output from the CPM WFP.

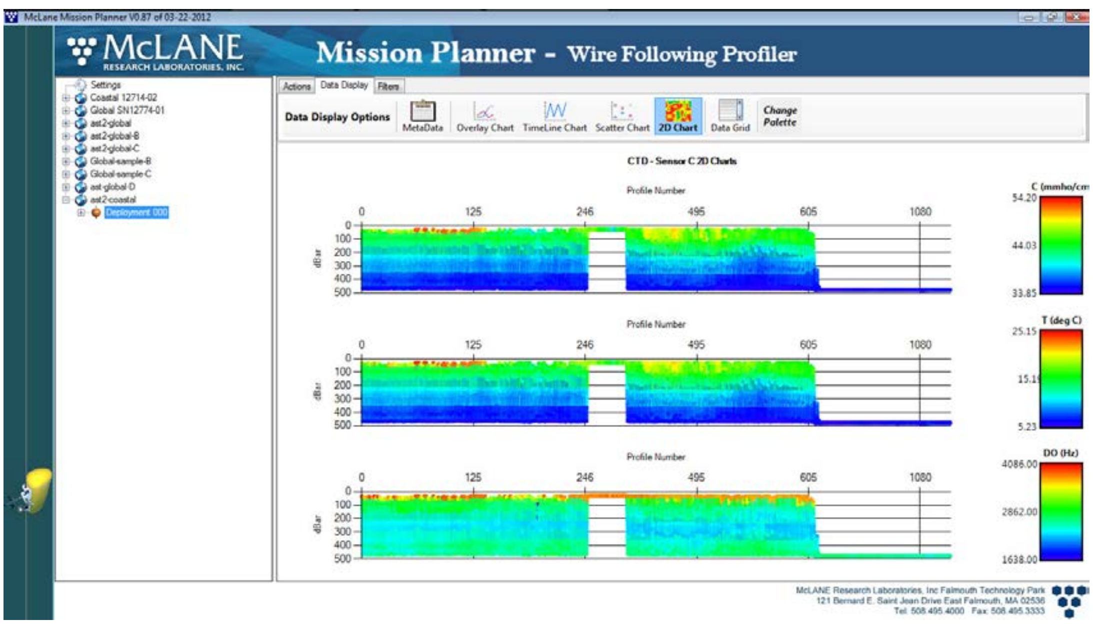


Figure 10: Conductivity, temperature, and dissolved oxygen data from the CPM WFP.

## II. Coastal Surface Mooring (CSM) Schematic and Recovery

The AST2 CSM consisted (Figure 11), from bottom to top, of a Benthic Anchor Recovery Frame (BARF), a Universal Joint, a series of EM stretch hose and buoyancy units, an EM cable, a subsurface instrument frame, chain, a Universal Joint, and a surface buoy.

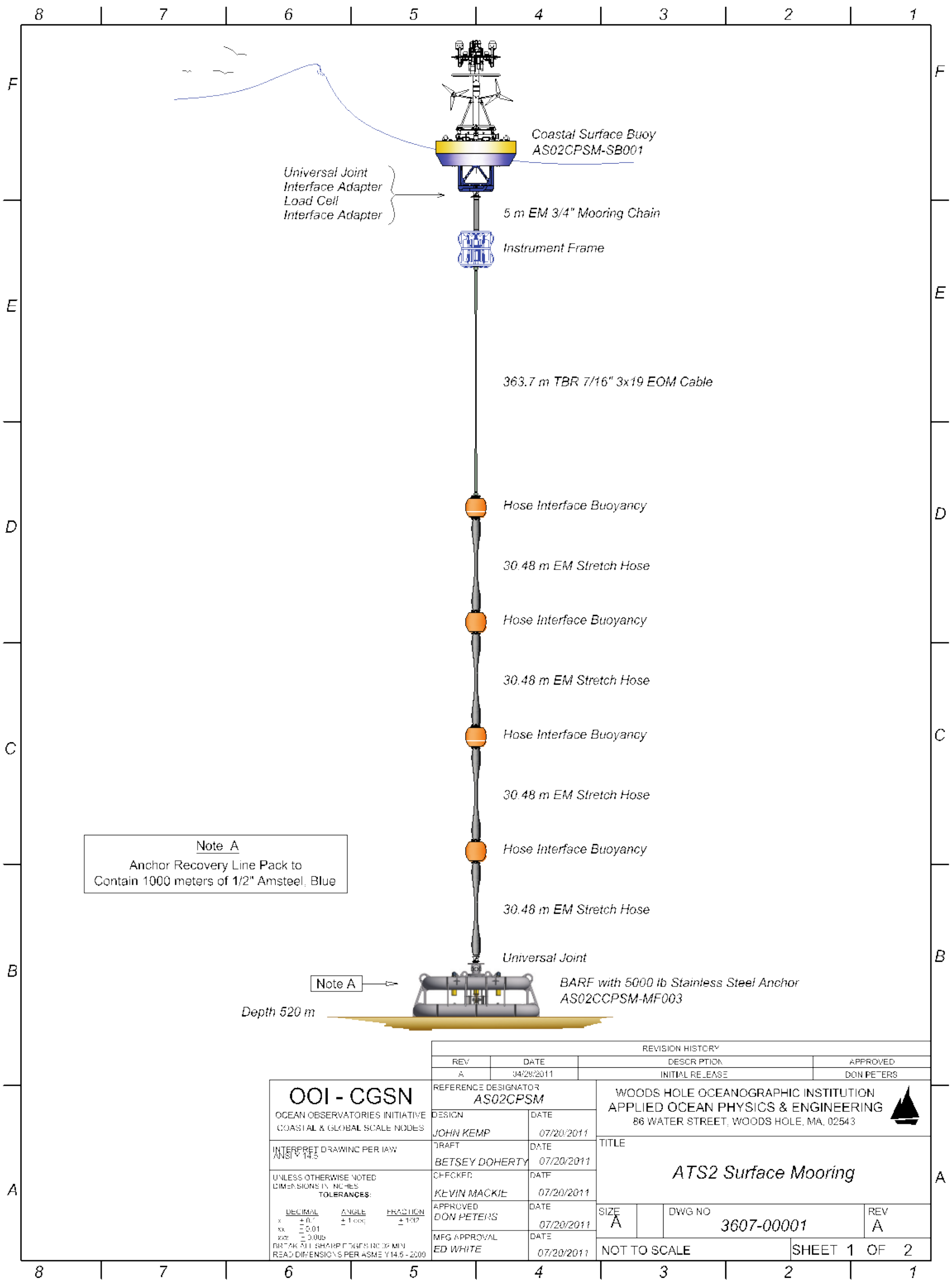


Figure 11: Coastal Surface Mooring (CSM) as deployed in AST2.

The recovery proceeded as follows. Contact was made with the acoustic release and the release was tripped. The recovery was intended from the bottom up, but the BARF never surfaced because of the current, so that the recovery proceeded instead from the top down, beginning with the surface buoy and ending with the BARF.

### A. Lessons Learned

#### i. General

- Conditions during the AST2 deployment and recovery cruises were benign, and more difficult conditions during the Construction and the Operations & Maintenance phases of the program might cause problems not experienced during the AST2 cruises.
- A number of on-deck operations executed at sea during the recovery cruise would have been impossible under difficult conditions and could have been done onshore, which would have sped up the at-sea activities as well as promoting safety.
- The recovery cruise indicated that only one recovery per day should be planned for the immediate future.
- A Global Class Research Vessel with Dynamic Positioning is recommended to provide adequate deck space and capability.
- An experienced team is required to perform the recovery operations.
- The deck set-up and sequence of activities should be reexamined and possibly changed to increase efficiency.
- Research Vessel Connecticut is a good resource for inspections and repair operations requiring modest capability.
- Fishing operations (both drifting and active) are extensive at the Pioneer Array site (Figures 12 and 13).
- Biofouling was heavy (Figure 14).
- Deformation occurred on some hose terminations (Figure 15) caused by pressure at depth.
- Castors on deck carts (Figure 16) should be replaced by fixed tracks.
- Placement of antennas and 100 to 150 feet of cable on deck needs to be planned to optimize on-deck operations and provide protection in heavy weather.
- Corrosion occurred on some mechanical connections (Figure 17) and should be better protected with anodes or changed to titanium.

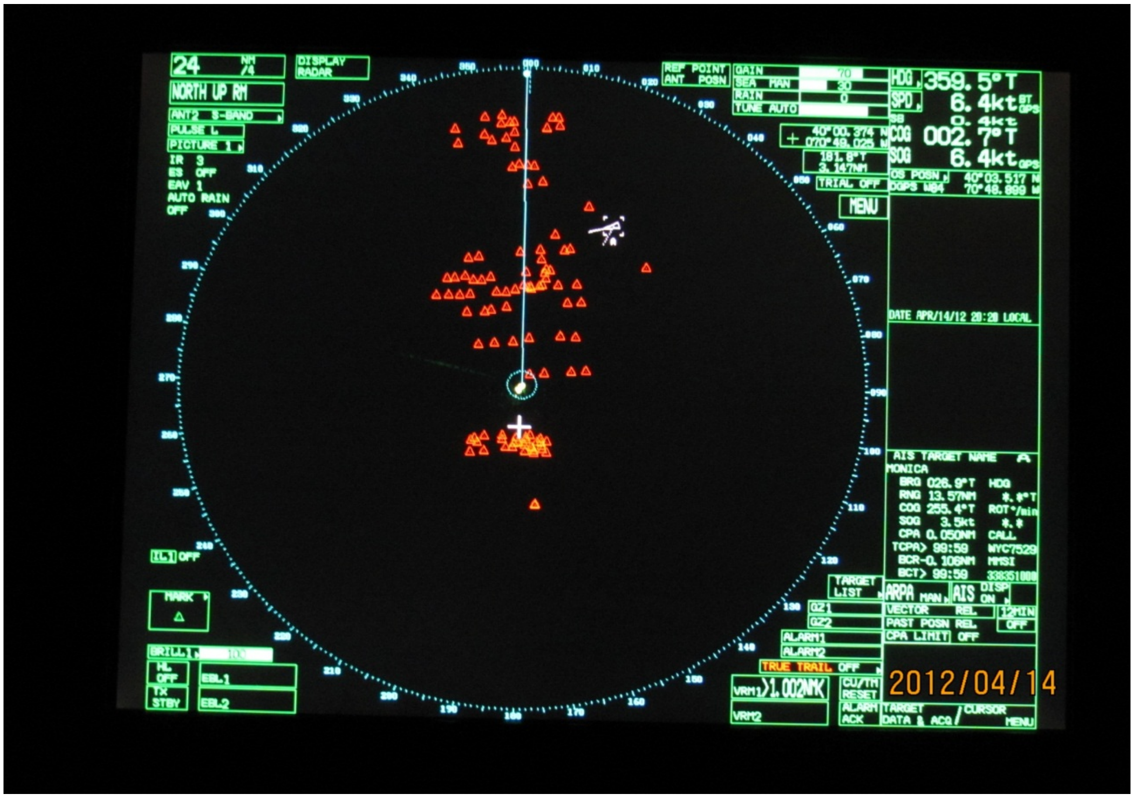


Figure 12: Radar screen shot showing extensive targets related to fishing activity.

Figure 13: Fishing line recovered from AST2 mooring.

Figure 14:  Example of biofouling,.

Figure 15:  Deformation of hose termination caused by pressure.

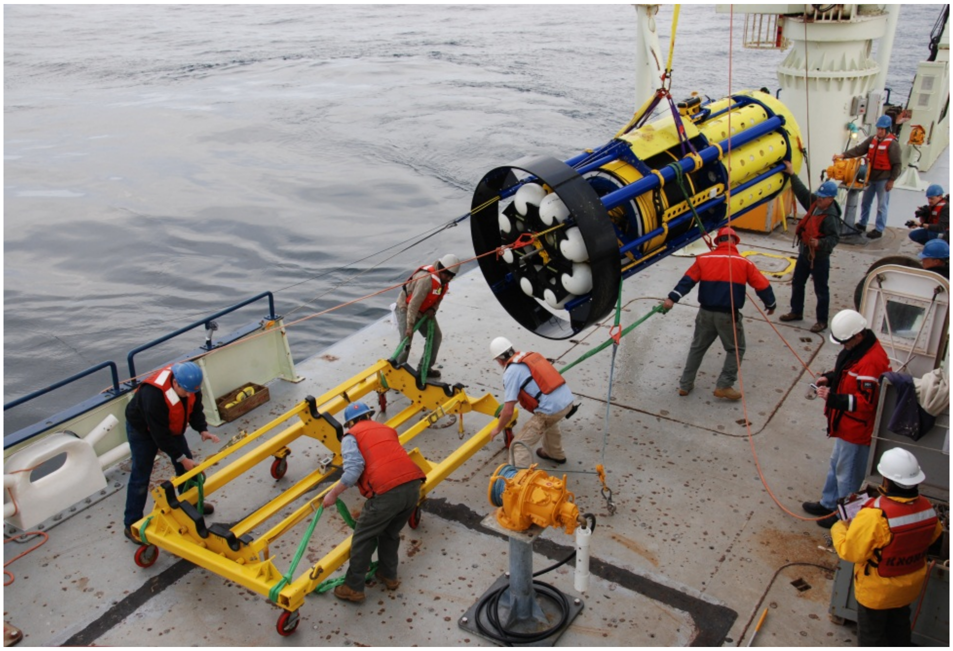

Figure 16: Note castors on deck carts, which were problematic and should be replaced by fixed tracks.

Figure 17: Example of corrosion of a bolt on an end cap.

ii. Coastal Profiler Mooring (CPM)

Examination of the CPM after recovery indicated a broken Kevlar member (Figure 18) in the stretch hose and a nick in a jacketed wire (Figure 19), which did not cause problems with inductive communications. The release system should be modified so that the mooring and anchor can be recovered separately.

Figure 18: Photo of broken Kevlar member on AST2 CPM.

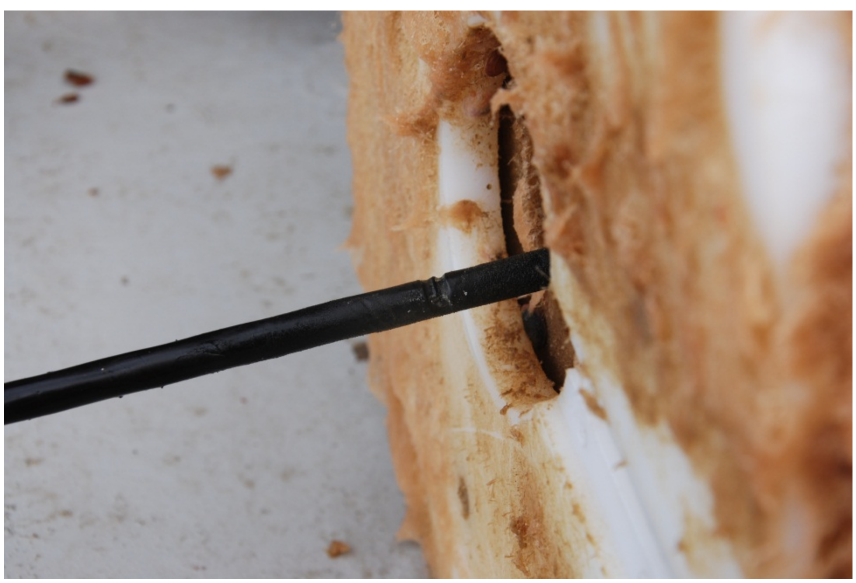

Figure 19: Photo of nick in jacketed wire on AST2 CPM.

The analysis of the stalled WFP on the CPM was as follows. The unit was brought into the Main Lab and tied down on April 12, 2012 at 1100 EDT. At 1200 EDT the WFP woke as scheduled for its next profiler, and the sensors started but there was no motor movement. At 1210 EDT the operator plugged a laptop into the WFP serial port, canceled the deployment, went to the bench-test menu and ran a motor test. There was no movement and the motor appeared to have braked or seized. A brake release command was sent but the motor remained stuck. The skin was pulled off the motor connector, which was rusty on one side. The motor housing was removed from the WFP, and the motor housing connector was bubbling and leaking water. The end cap bolts were turned ½ turn, and the end cap was under pressure. Further action was delayed to let the pressure dissipate. On April 13 at 1800 EDT the end cap was removed. The housing was full of water and there was corrosion (Figure 20), including a fully corroded capacitor. It was clear that a failed Impulse connector caused the flood. The Impulse connector mounted in the end cap might have been over-torqued prior to deployment, separating the neoprene jacket from the stainless steel body.

Figure 20: Corrosion on CPM WFP unit.

Additional notes: It would be productive to have a way of instructing the web interface on the WFP to display only the last N days of data, which might allow for faster web display when working with poor internet connection; the web display as currently configured was almost unusable with slow internet capability. A GUI web interface for sending SBD messages to the WFP would be useful. Buoy control and monitoring are not possible without internet connection, which could be problematic under some conditions.

iii. Coastal Surface Mooring (CSM)

The mast on the surface buoy broke off during the at-sea period and required a temporary tower with a light to be attached. The surface buoy had only about 10 inches of freeboard (Figure 21) making it wet enough to support biofouling growth. A fouled wet surface makes the deck slippery and difficult to work on at sea. The BARF surfaced upside down (Figure 22). The release system should be modified so that the mooring and BARF can be recovered separately.

Figure 21: Photo of surface buoy on AST2 CSM just prior to recovery, showing absence of the mast and small freeboard. Note the deck is biofouled and slippery due to the low freeboard.

Figure 22: Photo of BARF surfacing upside-down during recovery.

iv. Endurance Array

The AST2 Coastal Profiler Mooring (CPM) is the conceptual design for the Endurance Washington Offshore Profiler Mooring, and the AST2 Coastal Surface Mooring (CSM) is the conceptual design for the Endurance Shelf and Offshore surface moorings on the Oregon and Washington line shelf and offshore sites. The assumptions for the Endurance Array applications are that the vessel will be intermediate class (probably R/V Oceanus) and the operations will meet UNOLS Appendix A and B requirements.

A BARF is unnecessary on the Oregon Endurance Line for the Coastal Surface Mooring at the shelf and offshore sites as no instruments will be attached to the anchors of those moorings. All benthic instruments at those sites will be instead on the BEP connected to the RSN cable. Possible re-design of these moorings include:

- wire rope leading to glass balls on 3 m of ½" chain,
- 5 sets of dual glass balls on 2m of ½" chain,
- 3m of ½" chain,
- 5 ton swivel with bushings and anodes,
- reduced anchor weight to 3000 lb,
- possible inverse catenary in place of a stretch hose.

With removal of the BARF, the mooring recovery could be re-designed by taking the present dual acoustic release design and physically separating the releases. By placing one release in the mooring to release the mooring riser and surface buoy, the other release could be placed for releasing the line pack, enabling the preferred separate anchor recovery. Appropriate re-design of glass ball floatation would be required. Note: This same mooring re-design of the anchor recovery system could be used on the CPM, adding safety and reliability to the operations.

The Washington shelf and offshore sites as well as the inshore moorings (25m) on both the Oregon and Washington Lines will need a BARF to hold sub-surface instruments. Eliminating the BARF at the two Oregon sites however could decrease the required deck load and allow for fewer in port loading trips as well as decreasing shipping costs.

The Endurance Array will need mooring handling gear similar to the present deck equipment used during AST2. A partial list includes: heavy lift winch and deck mounting plate, load rated lowering line, bell-mouthed stern ramp, line spooler, air tugger winches and stands, turning blocks, buoy stands, lifting slings, aircraft straps, snap hooks, deck cleats and eyes, load rated (stop off) lines, shackles and links, load rated lowering line, acoustic release command units, strong back lowering release, acoustic releases, load rated mooring block, and large gear storage boxes.

Items of concern with respect to the Endurance Array include:

- Compliance with UNOLS Appendix B must be ensured with respect to the Heavy Lift Winch and the Amsteel Blue 5/8" Spectra.
- Deck space must be adequate.
- Lack of Dynamic Positioning on the R/V Oceanus could be problematic since the mooring is connected to the anchor throughout the deployment.
- No real dockside facility exists in Newport, so that the moorings will need to be trucked, with possible damage caused by vibration.
- Based on the WHOI dockside support facilities, the Endurance Array will need a dockside assembly/burn-in/storage facility within forklift driving distance to the vessel. Dedicated fork lifts (18K lbs and 4.5K lbs) will be required during cruises.
- The anchor recovery system needs to be "matured" to include the stern roller system. The A-frame and mooring block need to be within the UNOLS requirements. The anchor recovery system, using the stern roller, needs to be designed and tested.
- It would be best if the roller system could remain in place during operations.
- Does the R/V Oceanus have an air compressor capable of keeping up with the air tuggers?
- Seal fencing may be required to fend off seals from the solar panels and electrical connections. One possible solution would be to use a ring of solar panels with structural support pointed slightly down toward the water incorporating the panels as part of the fence. Reflection off the water can be fairly efficient if the angle is correct.
- Stainless steel crevice corrosion is potentially a concern in all near bottom hardware, in particular, between the anchor plates and for the BARF/MFN instrument mounting hardware. Oregon sites can go anoxic in summer. Silicon Bronze hardware is a possible replacement, but needs to be sized appropriately, as it is not as strong as stainless steel.
- The BARF and anchor need to completely separate for recovery operations. The anchor recovery and buoy/riser/BARF/MFN need to physically separate so that the recovery vessel can maneuver during recovery. In moderate conditions (as just

experienced during AST2 recoveries) the surface buoy is the initial item recovered. This leaves the vessel essentially anchored to the bottom, and adding additional tension to the mooring. Being able to freely maneuver, with the anchor separated, will add to the safety and reliability of recoveries.
Presently the BARF/MFN consists of buoyant segments secured with bracketing and bolts. A lower portion of the BARF/MFN's positively buoyant segments could be held in place with Magnesium bolts (which corrode in 7 days) during deployment. Following deployment, and corrosion of the Mg bolts, this independent segment could be held in place with appropriately designed bracketing from above, relying on the weight of the anchor for support once the Mg bolts are gone. This independent segment could be fixed to the anchor recovery line and separate when the BARF/MFN is released, The BARF/MFN, riser, and buoy could be recovered in one operation and the BARF/MFN segment and anchor in another, adding safety and reliability to the operations.

v. Photos and Imagery

The purpose and need for capturing images and stories from future OOI cruises will likely change as the project progresses. Currently, the need appears to be greatest for imagery that documents shipboard procedures and gathers forensic data for post-cruise analysis and reports. Forensic photography is a specialized field with a well-established set of protocols and equipment, some of which might be suited to OOI deployment and recovery cruises. Things like including a size scale in forensic photographs of failed parts would be relatively easy to implement and may prove especially important should equipment be further damaged on deck during transit back to shore. On the slightly more complicated (and costly) end of the scale, specific personnel could receive training in forensic and close-up photography, and some specialized photographic equipment (camera, lenses, lighting, tripod) might be acquired for the purpose of improving forensic and cruise documentation and in order to minimize variability.

As OOI progresses toward full implementation, the need for material that effectively communicates the purpose and benefits of the project to the general public will certainly grow, but that does not mean efforts to capture such imagery should be put off until need becomes greater. Capturing needed photographs and videos is hindered by the workman-like nature of mooring-based oceanography, which in turn contributes to its lack of iconic imagery. As scientists and communications professionals become accustomed to documenting OOI cruises, it is increasingly likely that more, higher quality images will result. Shipboard oceanography is, however, a notoriously difficult activity to document effectively without disrupting deck operations, and whoever is chosen to do this work should be accustomed to working on a research vessel and should be strongly encouraged to meet daily with the deployment/recovery team leader about the order of the day's events in order to plan their coverage. It would also be helpful if the photographer can contribute to some minimal shipboard activities (standing watch, helping deploy a CTD) so that they relive some burden from the rest of the science crew, but there should at the same time be allowance for them to fulfill their primary duties at any hour of the day.

It is also difficult to photograph over-the-side operations because much of the crucial activity takes place along open rails and facing away from deck. This challenge was somewhat overcome on this cruise by mounting a GoPro video camera in a waterproof housing on a 15-foot aluminum tagging pole and extending the camera over the stern and sides of the ship to video mooring and instrument recoveries. The technique met with some success, but was limited by the photographer's lack of experience with it and by shaking that was a result of the weight and flexibility of the pole. If this "polecam" technique is going to be a regular part of future cruises, some consideration should be given to acquiring a lightweight (fiberglass or carbon fiber) telescoping pole modified to accept a tripod ball socket head.

### vi. Education and Public Engagement (EPE)

Modern technology is rapidly changing the way we share, distribute, and process near real-time (NRT) information. Responding to this paradigm shift of access to information, undergraduate geoscience educators are beginning to incorporate NRT data into their lessons in order to teach and reinforce core concepts. The Ocean Observatories Initiative (OOI), with its Coastal, Regional, and Global Scale Nodes and advanced cyberinfrastructure (CI), will provide such educators with unprecedented access to NRT and archived ocean data and information. The Education and Public Engagement (EPE) component of the OOI, led by Rutgers University, will leverage this cyberinfrastructure to develop web-based tools and services for undergraduate educators that will allow them to easily and routinely incorporate OOI data into their lessons.

Over the next three years EPE will focus on the development of several online tools and services including educational visualization tools, a concept map builder, a lab-lesson builder, an educational resource database and a collaboration portal for students and educators. Collectively, these tools and services will provide educationally appropriate visualizations of science data, help to translate OOI science concepts into education materials, deliver the capability to collaboratively build and edit online lab-lesson units, enable virtual collaboration and sharing of oceanographic data and learning materials, and help to facilitate broader access to data and educational resources through EPE web services.

EPE is currently in the second phase of its Release 2 (R2) construction. During R2 construction EPE will develop a series of easy-to-use customizable visualization tools that allow students and educators the opportunity to explore scientific datasets. Examples of such tools include a Time Series Explorer tool that allows users to compare time series data for multiple months to investigate intra and inter-seasonal variability, a variable-variable comparison tool that allows users to investigate the relationship between, for example sea surface temperature and salinity at user defined temporal scales, and a profile explorer tool that allows a user to explore individual glider or profiler mooring profiles for a particular variable.

When developing such tools, it is best to develop them against stable, well described web services such as the NDBC sensor observation service or OOI CI web services. This allows developers to access data in common, consistent ways. OOI test deployments such as ISMT2, the glider product verification tests and AST2 are critical for testing, for example, the mechanical, electrical and communication components of mooring and glider designs. They are also important for showing end-to-end data flow from CGSN to CI and for showing wider project integration as EPE developers start to use OOI test data, delivered via CI web services, to develop R2 and R3 software tools and services. In addition to the utilizing OOI test data for visualization tool development, ancillary material such as photographs and video collected during test deployment and recovery cruises could be added to the educational resource database thereby allowing educators and students the ability to incorporate such materials into the concept maps and lessons they develop using the concept map and lab-lesson builder tools, respectively.

**References**

1. 1101-00000 OOI Final Network Design
2. 3207-00031 AST2 Deployment Cruise Report, WHOI Technical Report # 2012-03
3. Global Hybrid Profiler Mooring AST2 Recovery Report
4. 3204-00007 CGSN Site Characterization Pioneer Array (supporting ECR 1303-00434)
5. 3207-00003 At-Sea Test 2 Development Test (DT) Plan
6. 3207-00016 AST2 CPPM Wire Following Profiler Test Report, QLR
7. 3207-00022 Coastal Profiler Inductive Loop Riser Integration, QLR
8. 3208-00015 ISMT2 Engineering Report

**Acknowledgments**

Preparation for the AST2 deployment cruise involved many people across the WHOI , SIO and OSU teams and institutions.  Facilities, shop, and other support staff provided key help.  The officers and crew of *R/V Knorr* are thanked for their excellent support and participation in the AST2 recovery.  The CGSN effort of the OOI is funded by the National Science Foundation through a sub award from the Consortium for Ocean Leadership.

## Appendix 1: Cruise Participants

| Name | Role | Organization | Email |
|---|---|---|---|
| Dr. Robert A. Weller | Chief Scientist | WHOI | rweller@whoi.edu |
| Mr. John Lund | Technician | WHOI | jlund@whoi.edu |
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| Mr. James Dunn | Mooring Tech | WHOI | jdunn@whoi.edu |
| Mr. Jeff O'Brien | CPSM Tech | WHOI | jkobrien@whoi.edu |
| Mr. Ken Kostel | Communications | WHOI | kkostel@whoi.edu |
| | | | |
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| Ms. Gabriela Chavez | SIO O&M | SIO | gchavez@ucsd.edu |
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| | | | |
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| | | | |
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| Mr. Chris Holm | OSU Tech | OSU | cholm@coas.oregonstate.edu |
| Mr. Craig Risien | OSU EPE | OSU | crisien@coas.oregonstate.edu |
| | | | |
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| | | | |
| Mr. Fang-Hsu Kuo | Observer | Taiwan | francykuo@tori.narl.org.tw |
| Mr. Chao-Tsung Chiu | Observer | Taiwan | muddiapir@tori.narl.org.tw |
| | | | |
| Mr. Michael Mathewson | Vendor | McLane | mathewson@mclanelabs.com |

## Appendix 2: Mooring log – Coastal Pioneer Surface Mooring

# Moored Station Log

(fill out log with black ball point pen only)

ARRAY NAME AND NO. AST2 MOORED STATION NO. CPSM

### Launch (anchor over)

| | |
|---|---|
| Date (day-mon-yr) 24 SEPT 2011 | Time 16:34:30 UTC |
| Deployed by JOHN KEMP | Recorder/Observer JOHN LUND |
| Ship and Cruise No. R/V OCEANUS 475 | Intended Duration 7 MONTHS ∞ APRIL 2012 |
| Depth Recorder Reading 526.4 m | Correction Source MATTHEW TABLES |
| Depth Correction − 4 METERS m | |
| Corrected Water Depth 522.4 m | Magnetic Variation (E/W) |
| Anchor Drop Lat. (N/S) 39° 54.500 | Lon. (E/W) 070° 47.154 |
| Surveyed Pos. Lat. (N/S) | Lon. (E/W) |
| Argos Platform ID No. NA | Additional Argos Info on pages 2 and 3 |
| Acoustic Release Model ORE 8242XS | Tested to @ WHOI DOCK m |
| Release No. 1 (sn) 34578 | Release No. 2 (sn) 34580 |
| Interrogate Freq. 11 | Interrogate Freq. 11 |
| Reply Freq. 12 | Reply Freq. 12 |
| Enable A 122077 | Enable A 122163 |
| Disable 122106 | Disable 122201 |
| Release 134241 | Release 134313 |

### Recovery (release fired)

| | |
|---|---|
| Date (day-mon-yr) 13-4-2012 | Time 11:56 UTC UTC |
| Latitude (N/S) 39° 54.690 anchor survey | Longitude (E/W) 70° 47.~~xxx~~ 197 |
| Recovered by Kemp | Recorder/Observer |
| Ship and Cruise No. Knorr 206 | Actual duration days |

Distance from waterline to buoy deck 32 cm

1

**ARRAY NAME AND NO.** AST2 **MOORED STATION NO.** CPSM

## Surface Components

**Buoy Type** DISCUS **Color(s) Hull Tower** WHITE, SOLAR PANELS & WIND TURBINES

**Buoy Markings** YELLOW, BLUE BOTTOM PAINT ; WHOI NSF OOI
IF FOUND ADRIFT CONTACT WHOI CGSN OPERATIONS OFFICE...

## Surface Instrumentation


| Item | ID # | Height* | Comments |
|---|---|---|---|
| PRC | 224 | 78 cm | |
| HRH | 251 | 87 cm | |
| SWIND | 220 | 103 cm | |
| SWR | 239 | 127 cm | |
| LWR | 234 | 127 cm | |
| BPR | 228 | 72.5 cm | |
| PORT | | | |
| RFM | 0001 | | 879-7424 |
| GPS | 0001 | | 300234 010 446 400 |
| SBD | 0003 | | 300234010445320 ? |
| ISU | 0001 | | 8816-9248-9556 |
| IMEA | | | 300025010116940 |
| FLEET BROADBAND | | 120 cm | |
| XEOS | IMEI | 92 cm | 300034012197236 |
| STARBOARD | | | |
| RFM | 0003 | | 879-7838 |
| ISU | 0003 | | 8816-9248-9587 |
| SBD-IMEI | 0001 | | 300234016272270 |
| GPS | 0003 | | 1A3010262 |
| WIFI | 0001 | | AS2CPSM |
| FLEET BB | | 120 cm | |
| XEOS | IMEI | | 300034013906090 |
| | | | |
| WIND TURBINE | | 172 cm | |
| | | | |

*Height above buoy deck in centimeters

2

ARRAY NAME AND NO. AST2 MOORED STATION NO. CPSM

**Subsurface Instrumentation on Buoy and Bridle**

| Item | ID # | Depth† | Comments |
|---|---|---|---|
| XEOS KILO | | | 366234010510850 |
| SST | 8028 | -143 CM | |
| | | | |
| BIOFOULING, TEST PANELS ON BUOY FRAME | | | |
| | | | |
| INSTRUMENT FRAME (NSIF) | | | |
| WETLABS | DFLS | SN069 | |
| WETLABS | USFS | SN 05013 | |
| NORTEK | AQUADOPP | SN P23839-9 | |
| SBE | 16 PLUS V2 | SN 6841 | |
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†Depth below buoy deck in centimeters

3

ARRAY NAME AND NO. AST 2 MOORED STATION NO. CPSM

| Item No. | Length (m) | Item | Depth | Inst No. | Time Over | Time Back | Notes |
|---|---|---|---|---|---|---|---|
| 1 | | SURFACE BUOY | 0 | 13:47 | | 13:28 | MET, XMITTERS 0900 L FLASHER - ACTIVATED (?) ✓ 9/22 |
| 2 | 5m | 3/4" EM | - | 13:47 | | 13:40 | TURBINE SHOCK CORDS (?) ✓ |
| 3 | | INST FRAME | | 13:32 GMT | | 13:40 | REMOVE FLUOROMETER COVERS ! 0703 L 9/22 |
| 4 | 3637 | EOM CABLE ~~HIB~~ | ~ | 13:50→ | 14:31 | 15:10 | |
| 5 | | HIB | | | 14:31 | 15:10 | PLUG IN CTD PUMP (?) ✓ |
| 6 | 30.45 | EM HOSE (067) | | | 14:39 | 15:30 | CTD PLUGGED IN @ 12:47 L |
| 7 | | HIB | | | 14:39 | 15:30 | STEVE LERNER SHUT DOWN DCL |
| 8 | 30.45 | EM HOSE (064) | | | 14:45 | * 1607 | PORT → PUMP DRY ! |
| 9 | | HIB ① | | | 14:45 | 16:07 | S. LERNER TURNED PUMP ON |
| 10 | 30.48 | EM HOSE (068) | | | 14:53 | 16:20 | W/ CRANE ~ 15 min DRY |
| 11 | | HIB | | | 14:53 | 16:20 | |
| 12 | 30.45 | EM HOSE (065) | | | 15:37 | 16:58 | |
| 13 | | BARF | | | 15:37 | 16:58 | FLASHERS - ACTIVATED 0700 L 9/ |
| 14 | | ANCHOR | | | | 15:37 | RELEASES #1 34578 |
| 15 | | | | | | | #2 34580 |
| 16 | | | | | | | |
| 17 | ① | Crevice corrosion on HIB threaded rod! | | | | | 14:40 1.1 KNOTS THRU THE |
| 18 | | | | | | | WATER |
| 19 | | | | | | | @ 15:05 → 1:36 MINUTES TO |
| 20 | | | | | | | DROP SITE |
| 21 | |  69-2 | | | | | |
| 22 | | | | | | | 13:49 ≈ 40 min TO DROP |
| 23 | | | | | | | 16:05 ANCHOR @ 351 M |
| 24 | | | | | | | * Stopped for lunch |
| 25 | | | | | | | |

4

ARRAY NAME AND NO.________ MOORED STATION NO.________

| Item No. | Length (m) | Item | Depth | Inst No. | Time Over | Time Back | Notes |
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| Item No. | Length (m) | Item | Depth | Inst No. | Time Over | Time Back | Notes |
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ARRAY NAME AND NO.________ MOORED STATION NO.________

| Item No. | Length (m) | Item | Depth | Inst No. | Time Over | Time Back | Notes |
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7

ARRAY NAME AND NO.________ MOORED STATION NO.________

| Date/Time | Comments |
|---|---|
| anchor survey | Knorr 266 |
| | SM1 39° 54.5729 70° 47.0657 .793 |
| | SM2 39° 54.7619 70° 47.5349 .957 |
| | SM3 39° 54.2201 70° 47.7729 1.739 |
| | |
| | |
| • Fishing line damage on em-cable | 10' from top termination |
| • mono-filament | tangled on em-cable |
| | |
| 1 ?SE SN067 – | EOM CABLE EOM CABLE W/ DUMMIES + check grounding |
| | |

8

09C0135

## Appendix 3: Mooring Log – Coastal Pioneer Profiler Mooring

# Moored Station Log

(fill out log with black ball point pen only)

ARRAY NAME AND NO. AST2 MOORED STATION NO. CPPM

### Launch (anchor over)

Date (day-mon-yr) 23 SEPT 2011 Time 16:14 UTC

Deployed by JOHN KEMP Recorder/Observer JOHN LUND

Ship and Cruise No. RV OCEANUS 475 Intended Duration ~7MONTHS APRIL 2012

Depth Recorder Reading 526.1 m Correction Source MATTHEW'S TABLES

Depth Correction – 4 m

Corrected Water Depth ______ m Magnetic Variation (E/W) ______

Anchor Drop Lat. (N/S) 39° 54.570 Lon. (E/W) 70° 47.887

Surveyed Pos. Lat. (N/S) ______ Lon. (E/W) ______

Argos Platform ID No. ______ Additional Argos Info on pages 2 and 3

Acoustic Release Model 8242 XS Tested to 300 m

| | |
|---|---|
| Release No. 1 (sn) 34815 | Release No. 2 (sn) 34817 |
| Interrogate Freq. 11 KHz | Interrogate Freq. 11 KHz |
| Reply Freq. 12 KHz | Reply Freq. 12 KHz |
| Enable 163500 (A) 0 (B) | Enable 163607 (A) 0 (B) |
| Disable 163523 | Disable 163624 |
| Release 146255 | Release 146307 |

### Recovery (release fired)

Date (day-mon-yr) 4/12/2012 Time 12:12 UTC

Latitude (N/S) 39° 54.681 survey anchor Longitude (E/W) 70° 47.853

Recovered by JOHN KEMP Recorder/Observer JOHN LUND

Ship and Cruise No. KNORR 206 Actual duration 201 days

Distance from waterline to buoy deck ______

1

ARRAY NAME AND NO. AST 2 MOORED STATION NO. CPPM

## Surface Components

Buoy Type GAM Color(s) Hull Tower YELLOW

Buoy Markings YELLOW TOP / BLUE BOT

## Surface Instrumentation

| Item | ID # | Height* | Comments |
|---|---|---|---|
| WIFI | 3712-00106 | | UPDATED 4/13/2012 |
| SBD | 3712-00103 | SN 0002 | ~~[illegible]~~ 300234010626270 |
| RFM | SN 0002 | 3712-00104- | 00001 879-7597 |
| GPS | SN 0001 | 3712-00105- | 00001 1A 301 0266 |
| R. ENHANCER | SN 0329 | | |
| IRIDIUM ISU | SN 0002 | IMEI 3000 | 250 1011 2090 |
| | | SIM 89881 | 6922 4000 607110 |
| | | | |
| | Freewave | test | CPPM |
| | | | wireless wireless 39°55-2031 |
| | | | 070 49.0398 |
| | | | |
| | | | Freewave failed 39°56.1303 |
| | | | 70° 50.3787 |
| | | | ~2.53nm |
| | | | |
| | | | Flashing light recovered |
| | | | working! |

*Height above buoy deck in centimeters

ARRAY NAME AND NO. AST2 MOORED STATION NO. CPPM

## Subsurface Instrumentation on Buoy and Bridle

| Item | ID # | Depth† | Comments |
|---|---|---|---|
| | 21589 | -1.8 M | |
| | | | |
| | | | |
| | | | |
| | | | |
| INST FRAME | | | |
| SBE37 | 37IM 64183 | 8523 | SN 8523 |
| RDI | SN 15481 | ~ 480 M | 75 KHz |
| | | | |
| 64" SPHERE | | ~ 18 M | |
| TWR 2050 | 21590 | ~ 18 M | |
| XEOS | | | 300234010529920 |
| | | | |
| MMP | SN ML 12714-01 | | |
| SBE-52MP | SN 0093 | | |
| SBE-43F | SN 0209 | | |
| MAVS | SN 10300 | | MAVS 40P0.C |
| BBFL2 | SN 830 | | |
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†Depth below buoy deck in centimeters

3

ARRAY NAME AND NO. AST 2 MOORED STATION NO. CPPM

| Item No. | Length (m) | Item | Depth | Inst No. | Time Over | Time Back | Notes |
|---|---|---|---|---|---|---|---|
| 1 | | BUOY | 0 | | 09:18 | 13:23 | SUBMERSIBLE SURFACE BUOY |
| 2 | 15.2 | EM-STRETCH HOSE | | | 09:34 ② | 13:47 | PLUG IN INDUCTIVE LINK? |
| 3 | | | 17.1 M | TWR 21590 | | | TWR ON 64" SPHERE |
| 4 | | 64" SPHERE | | CA SGB 0002 | 0934 ③ | 13:53 | FLASHER ✓ 0700 & 9/22 |
| 5 | 3M | EM-CHAIN | | | 09:34 ① | 14:00 | * EM HOSE DAMAGE ≈ CENTER |
| 6 | | UPPER BUMPER | 24 M | | 09:34 | 14:11 | WIRE NICK 6' TOP TERMINATION |
| 7 | 451 M | MMP ON WIRE | | ML 12714-01 | 14:19 | 14:53 | WIRE FOLLOWING PROFILER |
| 8 | | LOWER BUMPER | 473 M | | 15:00 | 14:53 | current ≈ 1 knot |
| 9 | | ADCP | | | 15:00 | 14:54 | |
| 10 | | SBE 37 IM | | 8523 | 15:00 | 14:54 | NOTE: MMP DIVE @ |
| 11 | 20 M | 3/8 WIRE | | 11129-4 | 15:05 | 15:04 | WOULD BE 20 UTC |
| 12 | 3 M | 1/2 CHAIN | | | 15:05 | 15:04 | 4 PM local |
| 13 | | 4 BALL SET | | | 15:06 | 15:04 | ADJUST IF NEEDED |
| 14 | | 4 BALL SET | | | 15:09 | 15:04 | |
| 15 | | 4 BALL SET | | | 15:09 | 15:05 | MAGNET NOT REMOVED! |
| 16 | | 4 BALL SET | | | 15:10 | 15:05 | ON BUOY → BUOY IN |
| 17 | | 4 BALL SET | | | 15:10 | 15:10 | H2O ∴ → SMALL BOAT → |
| 18 | 3 M | 1/2 CHAIN | | | 15:19 | 15:10 | GO AROUND FOR RECOVERY |
| 19 | | 5 TON SWIVEL | | | x | | ON TRACK @ 2:03 GMT |
| 20 | | DUAL RELEASE | | 34817 34815 | 15:23 | 15:15 | 5.4 KM |
| 21 | 3m | 1/2 CHAIN | | | | 15:16 | W/ LINE PACK 34815 |
| 22 | | 5200 LB MACE ANCHOR | | | 15:26 | | |
| 23 | | | | | | 17:35 | MMP PROFILE DIVE # = NEXT |
| 24 | | | | | | | 1500 |
| 25 | | | | | | | STOPPED FOR LUNCH + CLEAN UP DECK. |

4

ARRAY NAME AND NO.________ MOORED STATION NO.________

| Item No. | Length (m) | Item | Depth | Inst No. | Time Over | Time Back | Notes |
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ARRAY NAME AND NO.________ MOORED STATION NO.________

| Item No. | Length (m) | Item | Depth | Inst No. | Time Over | Time Back | Notes |
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ARRAY NAME AND NO.________ MOORED STATION NO.________

| Item No. | Length (m) | Item | Depth | Inst No. | Time Over | Time Back | Notes |
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7

ARRAY NAME AND NO. AST2 MOORED STATION NO. CPPM

| Date/Time | Comments |
|---|---|
| 15:50 | SPHERE UNDER WATER |
| | |
| | SEND RELEASE CODE @ 20M PAST TARGET |
| | |
| | DEPTH @ TARGET |
| | |
| | Anchor survey on Knorr 206 |
| | PM1 39° 54.5661 70° 47.0439 1.709 |
| | PM2 39° 54.8561 70 47.3970 1.205 |
| | Pm3 39° 54.1971 70 47.7354 1.411 |
| | PM4 39° 54.8516 70 48.5259 1.521 |
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## Appendix 4: Mooring Log – Global Hybrid Profiler Mooring

# Moored Station Log

(fill out log with black ball point pen only)

ARRAY NAME AND NO. AST 2 MOORED STATION NO. HYPM

### Launch (anchor over)

| | |
|---|---|
| Date (day-mon-yr) 25-09-2011 START | Time 26-09-2011 00:31:10 RELEASE UTC |
| Deployed by KEMP/BEGLER/SIDDALL | Recorder/Observer A. CHAVEZ |
| Ship and Cruise No. OCEANUS 475 | Intended Duration APRIL 2012 |
| Depth Recorder Reading 2484 m | Correction Source MATTHEW'S TABLES |
| Depth Correction MINUS -16 m | |
| Corrected Water Depth 2468 m | Magnetic Variation (E/W) |
| Anchor Drop Lat. (N/S) 39° 28.782' | Lon. (E/W) 70° 48.940 |
| Surveyed Pos. Lat. (N/S) | Lon. (E/W) |
| Argos Platform ID No. | Additional Argos Info on pages 2 and 3 |

| | |
|---|---|
| Acoustic Release Model ORE 8242XS | Tested to 490 m |
| Release No. 1 (sn) 34657 (AT 219 m) | Release No. 2 AND 3 (sn) 34635 / 34636 (PAIR @ BOTTOM) |
| Interrogate Freq. 11 KHZ | Interrogate Freq. 11 KHZ 11 KHZ |
| Reply Freq. 12 KHZ | Reply Freq. 12 KHZ 12 KHZ |
| Enable 140126 | Enable 140032 / 140074 |
| Disable 140143 | Disable 140057 / 140105 |
| Release 135675 | Release 135633 / 135656 |

### Recovery (release fired)

| | |
|---|---|
| Date (day-mon-yr) 04-11-2012 | Time 12:19:42 start again 12:21 UTC |
| Latitude (N/S) 39° 28.818 | Longitude (E/W) 70° 49.073 |
| Recovered by KEMP/BEGLER/SIDDALL | Recorder/Observer G. CHAVEZ |
| Ship and Cruise No. KNORR 206 | Actual duration 200 days |
| Distance from waterline to buoy deck | |

{39°28.669' 70°48.522'W 1 Confirmed 12:21:22
{Second Release (Recover mooring) Fired @ 14:26 same day 04-11-2012

ARRAY NAME AND NO.________ MOORED STATION NO.________

## Surface Components

Buoy Type____ Color(s) Hull Tower ______________

Buoy Markings________________________________________________

## Surface Instrumentation

| Item | ID # | Height* | Comments |
|---|---|---|---|
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*Height above buoy deck in centimeters

2

ARRAY NAME AND NO.________ MOORED STATION NO.________

| Subsurface Instrumentation on Buoy and Bridle | | | |
|---|---|---|---|
| Item | ID # | Depth† | Comments |
| | | | |
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| †Depth below buoy deck in centimeters | | | |

3

ARRAY NAME AND NO. AST2 MOORED STATION NO. HYPM

39° 25.336' N 70° 56.298' W 7.8NM SITE

| Item No. | Length (m) | Item | Depth | Inst No. | Time Over | Time Back | Notes |
|---|---|---|---|---|---|---|---|
| | | | | | | | ALL BEACONS ACTIVE ✓ |
| 1 | | COMM FLOAT | | | 19:57 | 12:50 | 23 m. cable to the inst float |
| 2 | | INSTRUMENT FLOAT | | | 19:00 | 12:50 | 27 m to the winch |
| 3 | | WINCH FLOAT | | | 19:37 | 12:37 | 97.8 m 3/16" WIRE |
| 4 | | AQUADOPP SN# 6239 | | 6239 | (19:43) | 13:07 | @ bottom of yellow wire |
| 5 | | 5M SWIVEL 1.5 t | | | (19:45) | 13:07 | Pulled back in at 19:55 due to |
| 6 | | COUPLER | | | (19:45) | | ind-comm was tested down @ 19:59 and it worked |
| 7 | | (1) ACOUSTIC RELEASE #34137 | w/ bypass | 34437 | (19:45) | 13:07 | There was some issue with the Christian serviced it Back in the water |
| 8 | | COUPLER | | | (19:45) | | inductive comm worked 19:15 |
| 9 | | CF 14-1000 | | | (19:45) | 15:07 | |
| 10 | 10 | 5/16" wire ind term | | # 11174-1 | | | |
| 11 | | 64" float w/ load cage & instruments | | | 20:28 | 15:07 | Beacon @ 156.875 mHz |
| 12 | 5 | EM-CHAIN | | | 20:19 (loaded chain) | 15:24 | ind comm on deck after bringing back bypass & fixing it By Ron in the |
| 13 | 2000 | 5/16" WIRE | | # 11156-2 | 23:02 | unplugged at 15:44 | FINISHED SPOOLING OUT & stopped for stopper + load cage |
| 14 | on WIRE | Profiler Stopper | | | | [illegible] wire at 17:49 | About 2m below EM-Chain |
| 15 | on WIRE | WIRE PROFILER w/ INST. | | | 20:49 | 18:59 | floor cap removed – all plugged placed after 500 m of wire spooled out |
| 16 | on WIRE | WIRE PROF STOPPER | | | 23:30 | Safety line up at 17:07 | immediately above the load cage |
| 17 | | load cage & lower Seaguard | | | 23:30 | 17:05 | 23:17 ind comm tested & worked |
| 18 | | Shackle Ring & Shackle (S-R-S) ✓ | | | | | END LINK |
| 19 | | load cell 10692-3 | ✓ | 10692-3 | 23:30 | | |
| 20 | | S-R-S | ✓ | | | | |
| 21 | 50 | 5/16" WIRE 11122-8 | | # 11122-8 | 23:30 23:34 | started pick up of lower buoy at 16:43 | |
| 22 | | PARACHUTE | | | 23:35 | 16:52 | |
| 23 | | S-R-S | ✓ | | | | |
| 24 | 20 | 5/16" WIRE | | # 11122-10 | 23:37 | | (Pages 2 & 3 blank) |
| 25 | | PARACHUTE | | | 23:38 | 16:48 | |

4

ARRAY NAME AND NO. AST2 MOORED STATION NO. HYPM

| Item No. | Length (m) | Item | Depth | Inst No. | Time Over | Time Back | Notes |
|---|---|---|---|---|---|---|---|
| 26 | | S-R-S | ✓ | | | | |
| 27 | 20 | 5/8" WIRE | | #11122-11 | 23:39 | | |
| 28 | | BARRAVANE | | | 23:43 | | |
| 29 | | S-R-S | ✓ | | | | |
| 30 | 5 | chain | | | 23:46 | | |
| 31 | | S-R-S | ✓ | | | | Some S-R-S @ first |
| 32 | | 4 glass balls | ✓ | | 23:48 | | went with nuts |
| 33 | | S-R-S | ✓ | | | | just finger-tight |
| 34 | | 4 glass balls | ✓ | | 23:48 | | until it was noticed |
| 35 | | S-R-S | ✓ | | | | and all were tightened |
| 36 | | 4 glass balls | ✓ | | 23:52 | | with a wrench after |
| 37 | | S-R-S | ✓ | | | | that |
| 38 | | 4 glass balls | ✓ | | 23:52 | | |
| 39 | | S-R-S | ✓ | | | 14:41 | → ALL CAME OUT IN A |
| 40 | | 4 glass balls | ✓ | | 23:53 | | TANGLED MASS. |
| 41 | | S-R-S | | | | | |
| 42 | | 4 glass balls | ✓ | | 23:57 | | |
| 43 | | S-R-S | ✓ | | | | |
| 44 | | 4 glass balls | | | 23:57 | | |
| 45 | | S-R-S | ✓ | | | | |
| 46 | | 4 glass balls | ✓ | | 23:57 | | |
| 47 | | SRS | | | | | |
| 48 | | 4 glass balls | | | 00:00 | | |
| 49 | | S-R-S | | | | | |
| 50 | | 4 glass balls | | | 00:01 | | |

5

ARRAY NAME AND NO.________ MOORED STATION NO.________

| Item No. | Length (m) | Item | Depth | Inst No. | Time Over | Time Back | Notes |
|---|---|---|---|---|---|---|---|
| 51 | | S-R-S | ✓ | | | | |
| 52 | 5 | Chain | ✓ | | 00:11 | | |
| 53 | | S-R-S | ✓ | | | | |
| 54 | | Swivel 5 ton | ✓ | | 00:11 | | |
| 55 | | S-R-S | ✓ | | | | |
| 56 | | ACOUSTIC RELEASE | | #34635 #34636 | 00:11 | 14:16 | |
| 57 | 1 | 1/2" deep chain | ✓ | | | | |
| 58 | | MASTER LINK | ✓ | | | | |
| 59 | | S-R-S | ✓ | | | | END LINK |
| 60 | 20 | Nystron 1" | | | | | 1 HR to go till deployment site |
| 61 | | S-R-S | ✓ | | | | END LINK |
| 62 | 5 | Chain | ✓ | | | | |
| 63 | | Shackle | ✓ | | | | |
| 64 | | ~~Parachute~~ | | | | | No parachute, lowering w/ |
| 65 | | | | | | | trawl winch. |
| 66 | | | | | | | to about 94 m and |
| 67 | | | | | | | dropped (released) |
| 68 | | | | | | | |
| 69 | | | | | | | |
| 70 | | | | | | | |
| 71 | | | | | | | |
| 72 | | | | | | | |
| 73 | | | | | | | |
| 74 | | | | | | | |
| 75 | | | | | | | |

6

ARRAY NAME AND NO.________ MOORED STATION NO.________

| Item No. | Length (m) | Item | Depth | Inst No. | Time Over | Time Back | Notes |
|---|---|---|---|---|---|---|---|
| 76 | | | | | | | |
| 77 | | | | | | | |
| 78 | | | | | | | |
| 79 | | | | | | | |
| 80 | | | | | | | |
| 81 | | | | | | | |
| 82 | | | | | | | |
| 83 | | | | | | | |
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| 85 | | | | | | | |
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| 88 | | | | | | | |
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| 95 | | | | | | | |
| 96 | | | | | | | |
| 97 | | | | | | | |
| 98 | | | | | | | |
| 99 | | | | | | | |
| 100 | | | | | | | |

7

ARRAY NAME AND NO. ________ MOORED STATION NO. ________

| Date/Time | Comments |
|---|---|
| | |
| | |
| | mean position surface float |
| | 39°N 28.65' |
| | 70° W 49.02 |
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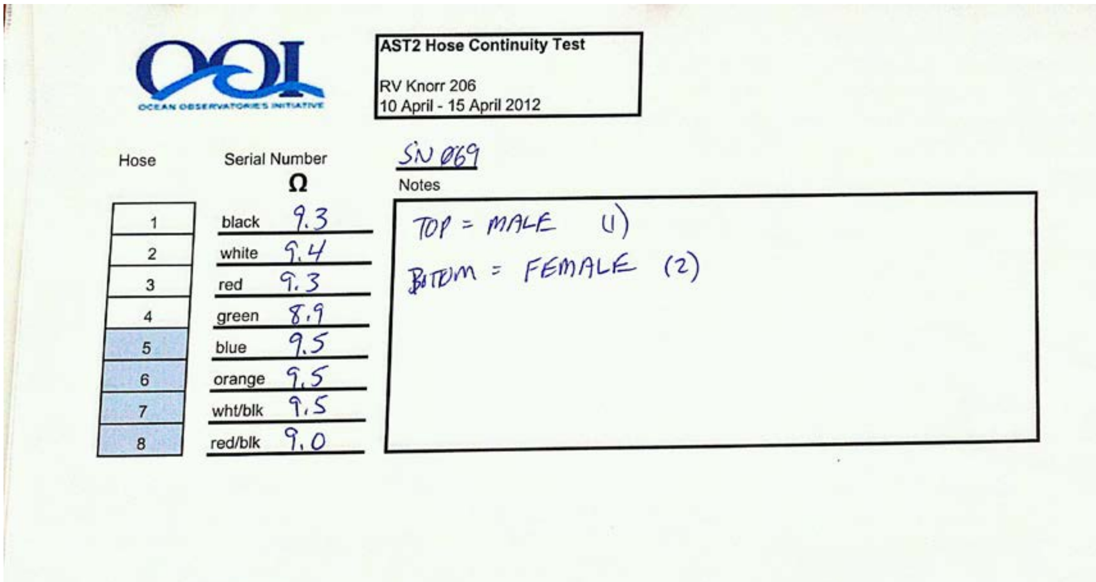
8

09/00135

## Appendix 5: Wiring



OCEAN OBSERVATORIES INITIATIVE

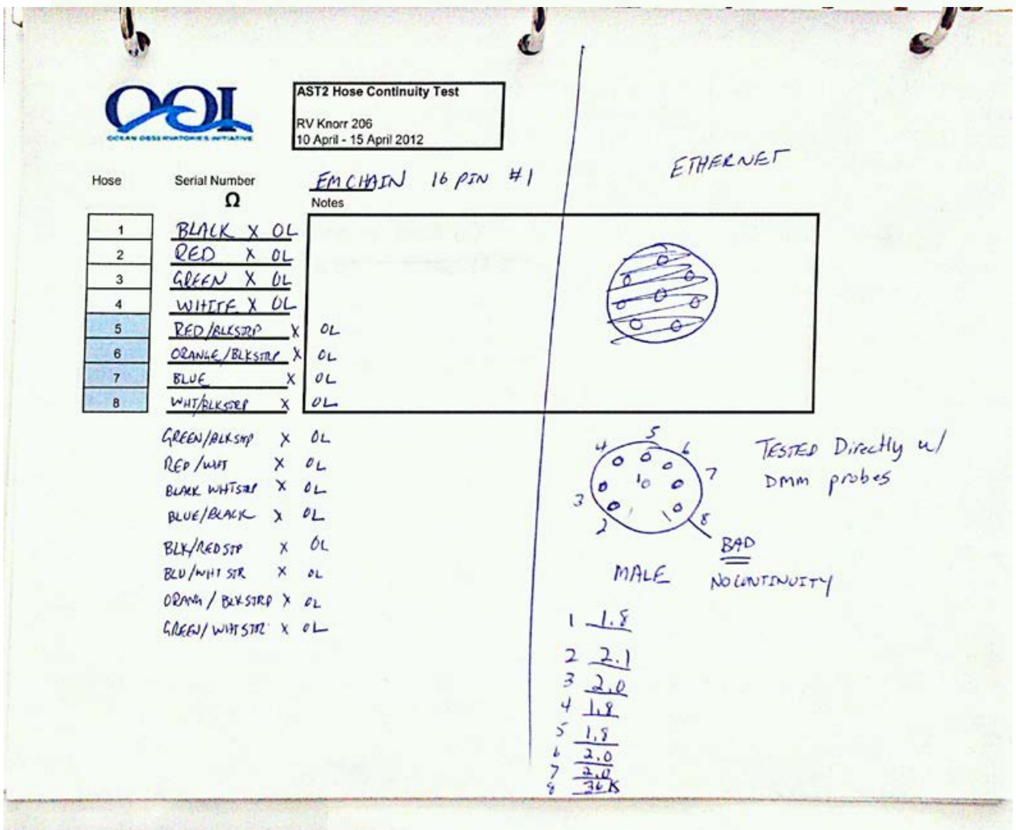
**AST2 Hose Continuity Test**
RV Knorr 206
10 April - 15 April 2012

SN 069

| Hose | Serial Number Ω | |
|---|---|---|
| 1 | black | 9.3 |
| 2 | white | 9.4 |
| 3 | red | 9.3 |
| 4 | green | 8.9 |
| 5 | blue | 9.5 |
| 6 | orange | 9.5 |
| 7 | wht/blk | 9.5 |
| 8 | red/blk | 9.0 |

Notes

TOP = MALE (1)
BTTOM = FEMALE (2)



OCEAN OBSERVATORIES INITIATIVE

**AST2 Hose Continuity Test**
RV Knorr 206
10 April - 15 April 2012

EM CHAIN 16 PIN #1

| Hose | Serial Number Ω | | |
|---|---|---|---|
| 1 | BLACK | X | OL |
| 2 | RED | X | OL |
| 3 | GREEN | X | OL |
| 4 | WHITE | X | OL |
| 5 | RED/BLKSTRP | X | OL |
| 6 | ORANGE/BLKSTRP | X | OL |
| 7 | BLUE | X | OL |
| 8 | WHT/BLKSTRP | X | OL |
| | GREEN/BLKSTRP | X | OL |
| | RED/WHT | X | OL |
| | BLACK WHTSTRP | X | OL |
| | BLUE/BLACK | X | OL |
| | BLK/REDSTP | X | OL |
| | BLU/WHT STR | X | OL |
| | ORANG/BLKSTRP | X | OL |
| | GREEN/WHTSTR | X | OL |

Notes

ETHERNET



TESTED Directly w/
DMM probes

BAD
NO CONTINUITY

1 1.8
2 2.1
3 2.0
4 1.8
5 1.8
6 2.0
7 2.0
8 36K

**AST2 Hose Continuity Test**

RV Knorr 206
10 April - 15 April 2012

EOM CABLE

| Hose | Serial Number Ω |
|---|---|
| 1 | ~~black~~ white 20.7 |
| 2 | white |
| 3 | red |
| 4 | green |
| 5 | blue |
| 6 | orange |
| 7 | wht/blk |
| 8 | red/blk |

Notes

9 - 16 → continuity

**AST2 Hose Continuity Test**

RV Knorr 206
10 April - 15 April 2012

SN068

| Hose | Serial Number Ω |
|---|---|
| 1 | black 9.3 |
| 2 | white 9.3 |
| 3 | red 9.3 |
| 4 | green 8.8 |
| 5 | blue 9.4 |
| 6 | orange 9.4 |
| 7 | wht/blk 9.4 |
| 8 | red/blk 8.9 |

Notes

TOP MALE (1)
BOTTOM FEMALE (2)
Termination squished

OCEAN OBSERVATORIES INITIATIVE

**AST2 Hose Continuity Test**

RV Knorr 206
10 April - 15 April 2012

EM-CHAIN

| Hose | Serial Number Ω |
|---|---|
| ~~1~~ | BLACK 0.6Ω |
| ~~2~~ | WHITE 1.2Ω |
| ~~3~~ | ORANGE 0.6Ω |
| ~~4~~ | BLUE 0.8Ω |
| ~~5~~ | GREEN 1.6 |
| ~~6~~ | RED X |
| 7 | |
| 8 | |

Notes

POWER

RED → NO SIGNAL

~~#~~1 PIN 3 DEAD!!

. Tested directly
. confirmed test cable!
. Confirmed test box

OCEAN OBSERVATORIES INITIATIVE

**AST2 Hose Continuity Test**

RV Knorr 206
10 April - 15 April 2012

11128-1 451 m CPPM INDUCTIVE CABLE

| Hose | Serial Number Ω |
|---|---|
| 1 | black ~~0.3~~ X |
| 2 | white ~~0.3~~ X |
| 3 | red ~~0.3~~ X |
| 4 | green ~~0.3~~ X |
| 5 | blue 3.3 |
| 6 | orange 3.4 |
| 7 | wht/blk 3.4 |
| 8 | red/blk 3.4 |

Notes

4/18/2012

☐ Pressure Wash EM-CHAIN

☐ Clean Pigtails

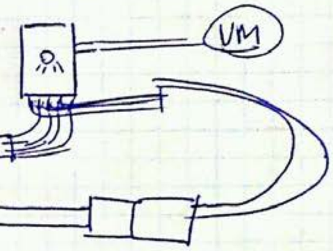
☐ Test Conductors → Same as ship

**POWER CABLE 6 PIN**

| | | |
|---|---|---|
| 1 | BLACK | X |
| 2 | WHITE | ✓ |
| 3 | RED | X |
| 4 | GREEN | X |
| 5 | ORANGE | X |
| 6 | BLUE | X |

**TEST the TESTER**

| | |
|---|---|
| 1 | .2 Ω |
| 2 | .2 Ω |
| 3 | .2 Ω |
| 4 | .2 Ω |
| 5 | .2 Ω |
| 6 | .2 Ω |




11" from the Chain termination in the universal bendy break

| | 16 cond #2 | | 16COND #1 | |
|---|---|---|---|---|
| 1 | BLACK | X | X | come on w/ bend |
| 2 | WHITE | X | X | |
| 3 | RED | ✓ | X | |
| 4 | GREEN | X | X | |
| 5 | ORANGE | X | X | come on w/ bend |
| 6 | BLUE | X | X | |
| 7 | WHT/BLK | X | X | |
| 8 | RED/BLK | X | X | come on w/ bend |
| 9 | GRN/BLK | X | X | |
| 10 | ORN/BLK | X | X | |
| 11 | BLU/BLK | X X | X | |
| 12 | BLK/WHT | X | X | |
| 13 | RED/WHT | X (w/ COMPRESSION) | X | |
| 14 | GRN/WHT | X (w/ COMPRESSION) | X | |
| 15 | BLU/WHT | X (w/ COMPRESSION) | X | |
| 16 | BLK/RED | X (w/ COMPRESSION) | X | |

**AST2 Hose Continuity Test**

RV Knorr 206
10 April - 15 April 2012

50' WHALE HOSE + JUMPER + EM CHAIN 3 M

| Hose | Serial Number Ω |
|---|---|
| 1 | BLACK 4.7 Ω |
| 2 | WHITE 4.8 Ω |
| 3 | RED 4.6 Ω |
| 4 | GREEN 4.8 Ω |
| 5 | BLUE 4.7 |
| 6 | ORANGE 4.9 |
| 7 | WHT/BLK 4.8 |
| 8 | RED/BLK 5.0 |

Notes

50' HOSE DAMAGED w/ SIZEABLE GASH DOWN TO QUADS!

**AST2 Hose Continuity Test**

RV Knorr 206
10 April - 15 April 2012

064

| Hose | Serial Number Ω |
|---|---|
| 1 | black 9.1 |
| 2 | white 9.1 |
| 3 | red 9.1 |
| 4 | green 8.6 |
| 5 | blue 9.3 |
| 6 | orange 9.3 |
| 7 | wht/blk 9.3 |
| 8 | red/blk 8.8 |

Notes

TOP = MALE (1)
BOTTOM = FEMALE (2)

OCEAN OBSERVATORIES INITIATIVE

**AST2 Hose Continuity Test**

RV Knorr 206
10 April - 15 April 2012

Serial Number: Ø67

| Hose | Ω | |
|---|---|---|
| 1 | black | 9.1 |
| 2 | white | 9.1 |
| 3 | red | 9.1 |
| 4 | green | 8.6 |
| 5 | blue | 9.4 |
| 6 | orange | 9.4 |
| 7 | wht/blk | 9.4 |
| 8 | red/blk | 8.9 |

Notes

TOP = MALE MCIL16M
BOTTOM = FEMALE MCIL16F
- Wrapping around the terminations is compromised hose looks bumpy.
- Anode are good
- in sections thru the middle hose looks flat.

OCEAN OBSERVATORIES INITIATIVE

**AST2 Hose Continuity Test**

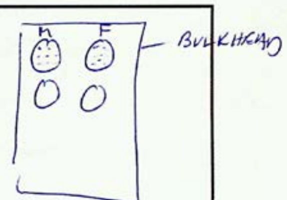
RV Knorr 206
10 April - 15 April 2012

Serial Number: EM-CHAIN 16 COND #2

| Hose | Ω |
|---|---|
| 1 | RED ✓ 1.5Ω |
| 2 | WHITE ✓ 20Ω |
| 3 | BLACK X 85Ω |
| 4 | GREEN ✓ 1.3Ω |
| 5 | BLUE X OL |
| 6 | ORANGE X OL |
| 7 | WHITE/BLK X OL |
| 8 | RED/BLK X OL |

Notes

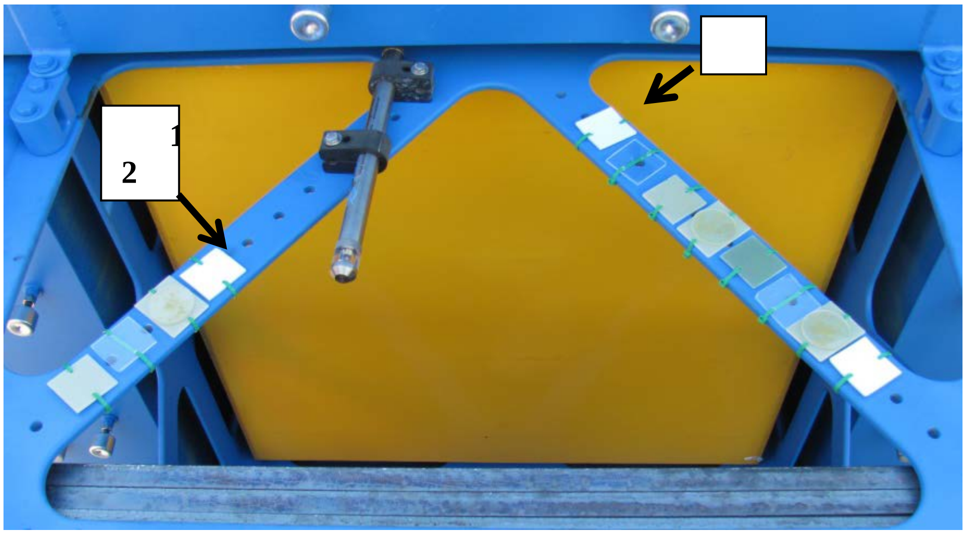
NEED TEST BOX




BLK / WHT X 80 Ω
RED / WHT X OL
GREEN / BLK X OL
BLUE / BLK X OL
BLK / RED stripe X OL
GREEN / WHITE stripe ✓ 1.4
ORANGE / BLACK stripe ✓ 6.4
BLUE / WHITE ✓ 2.0

**Appendix 5: Biofouling Slides – Surface Buoy**

Surface Buoy Slide numbered B 1-12 from the upper right clockwise:



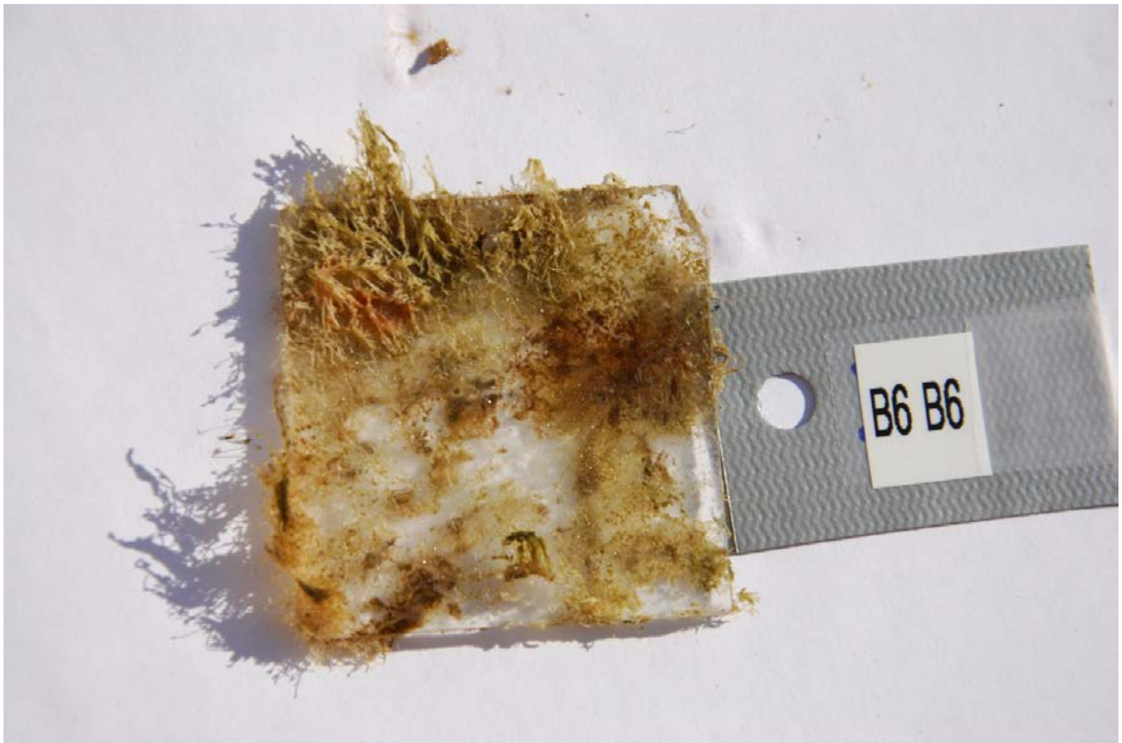


B2 B2


B3 B3


B4 B4


B5 B5


B6 B6

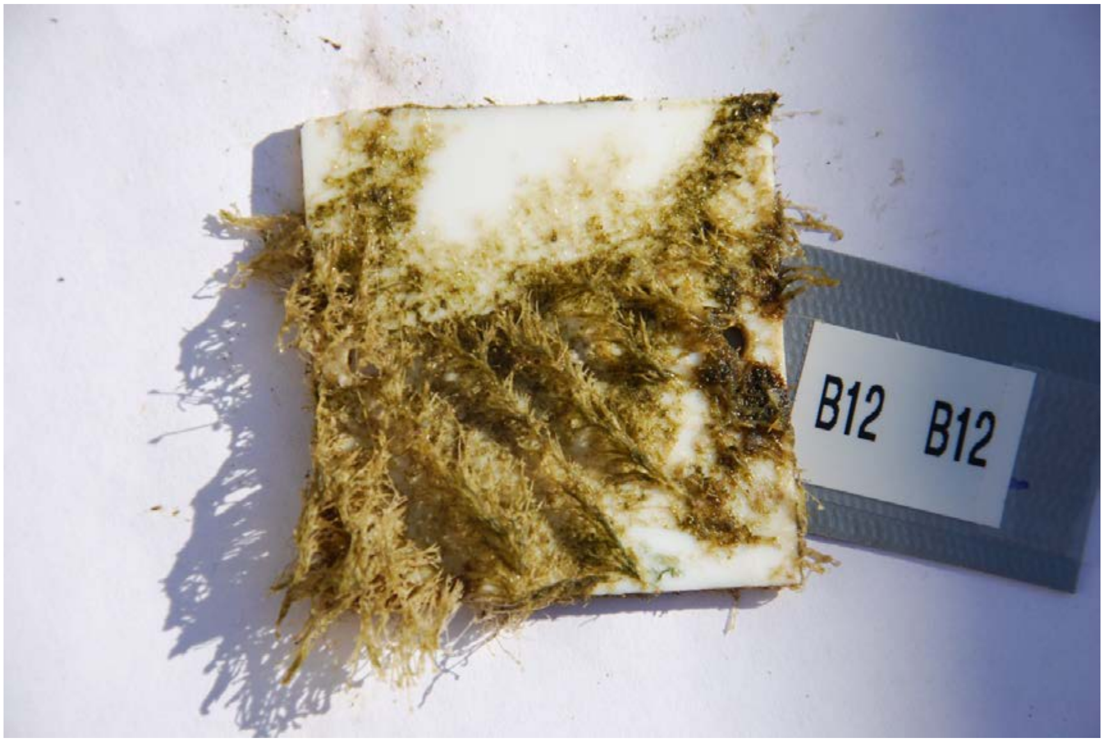

B7 B7


B8 B8


B9 B9

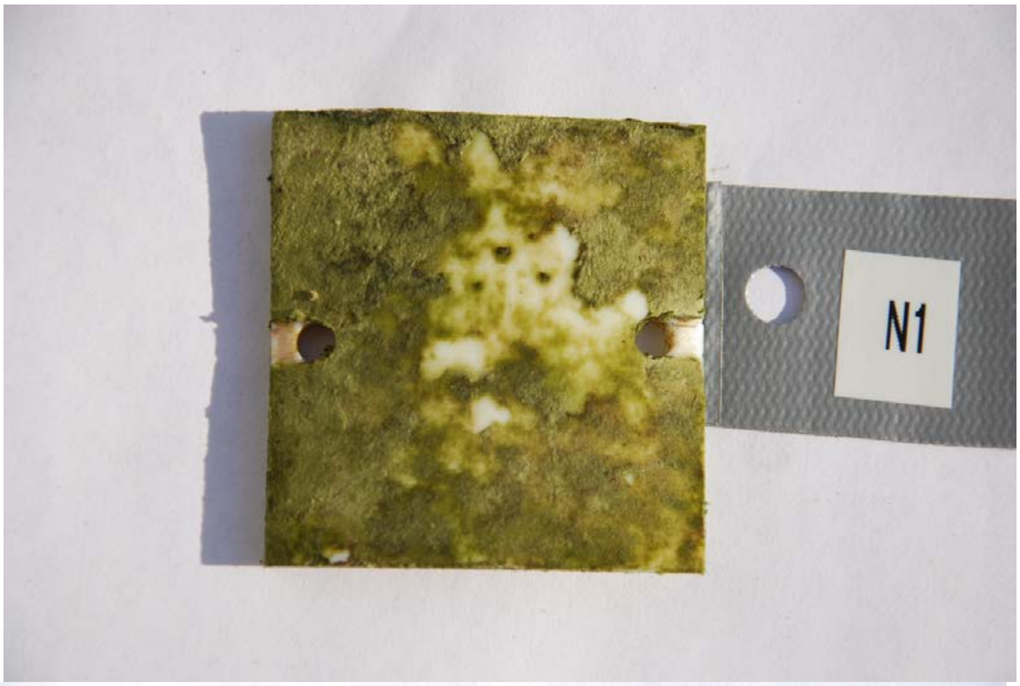

B10 B10

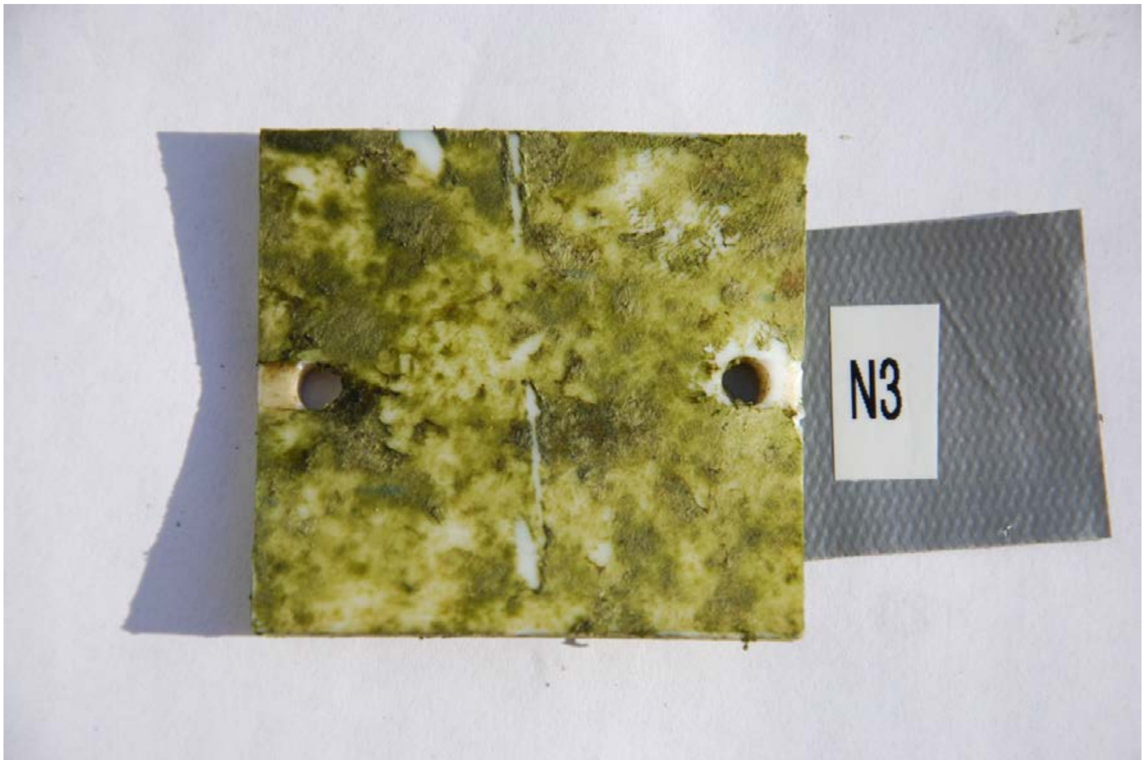

B11 B11

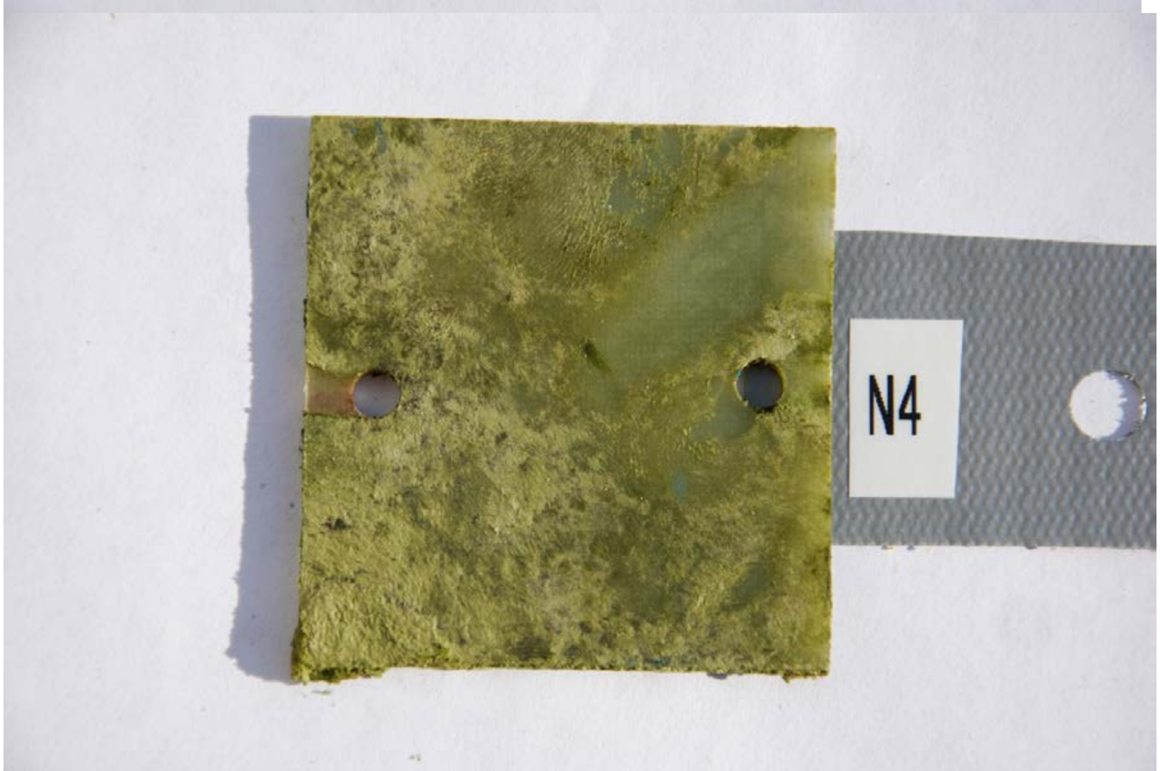

B12 B12

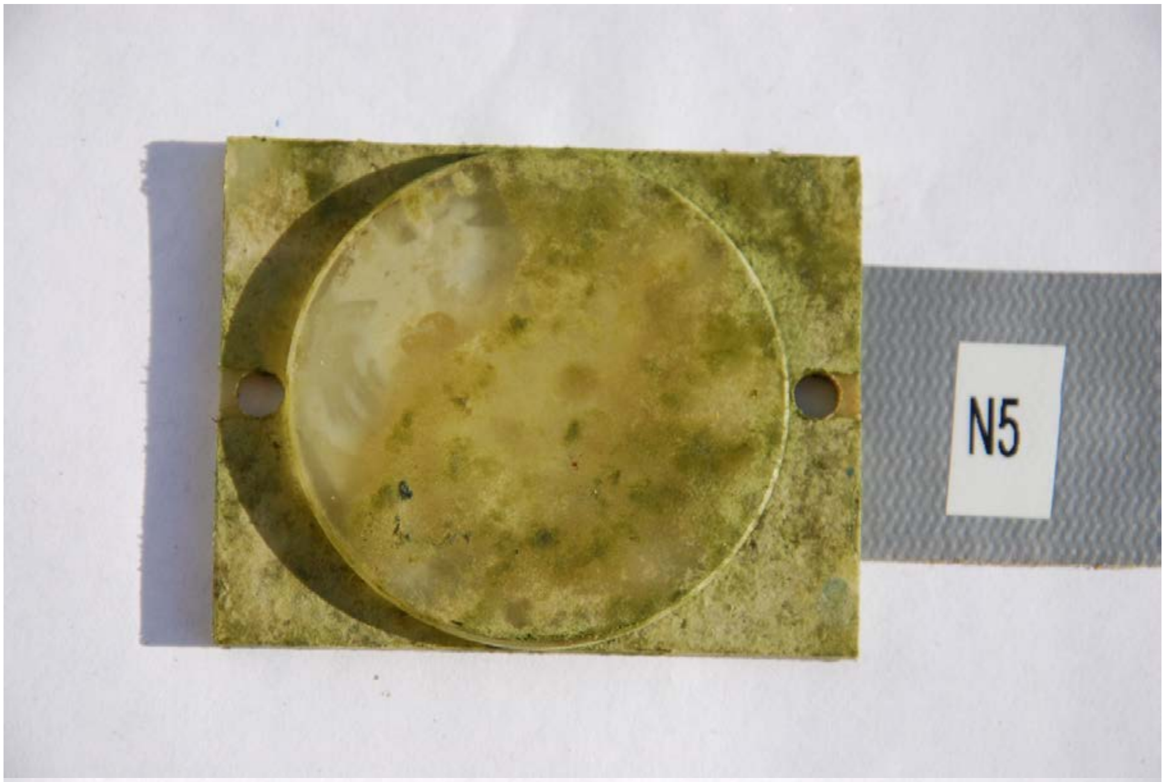
## Appendix 6: Biofouling Slides - NSIF

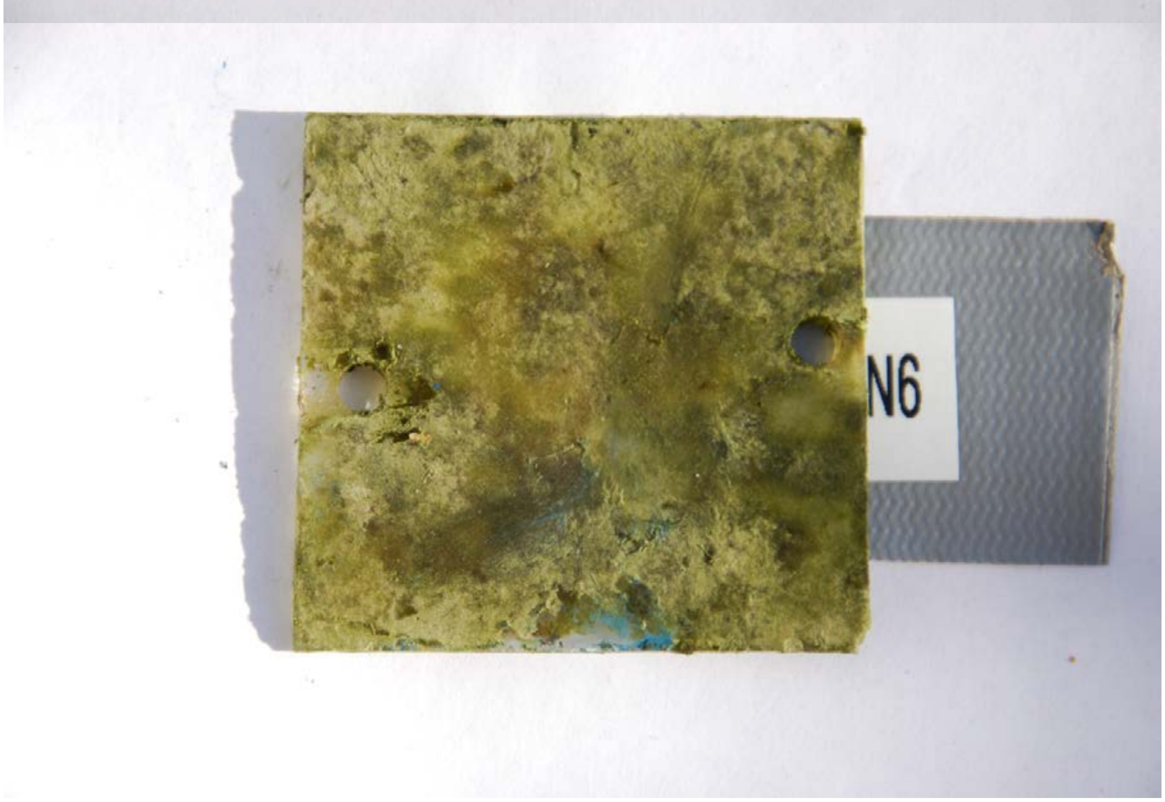
Near Surface Frame NSIF slides, numbered N 1-12 from the upper right clockwise:

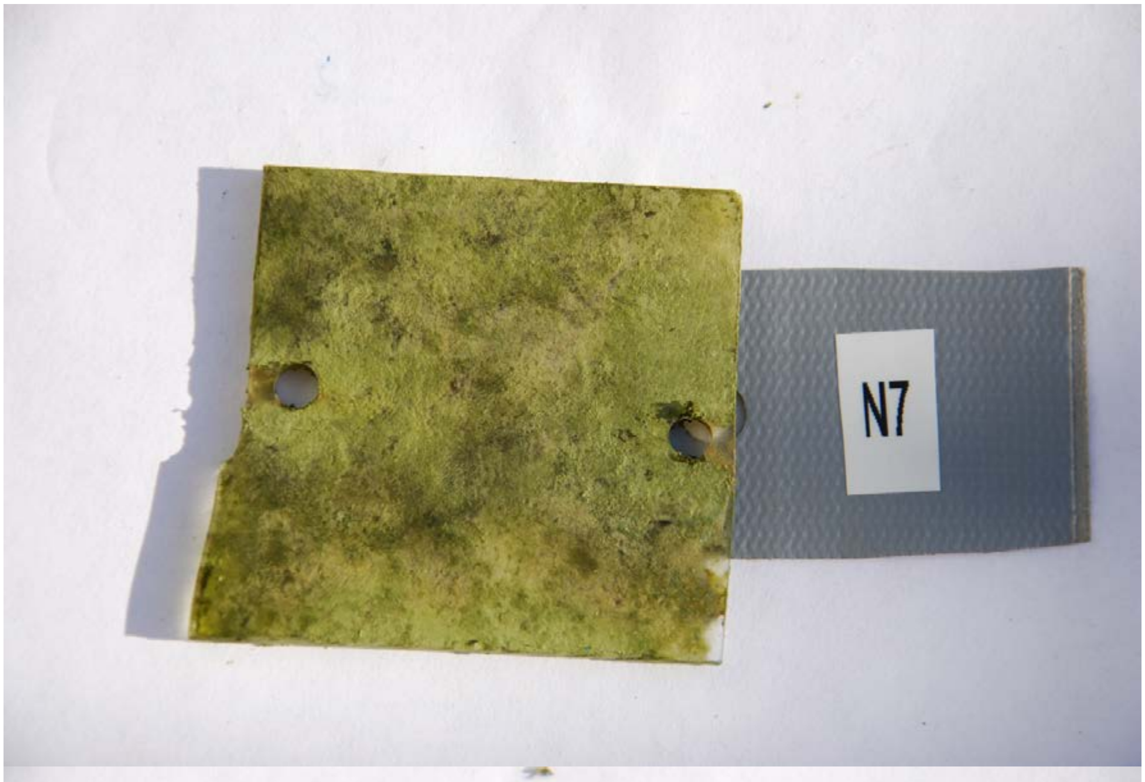




N3


N4

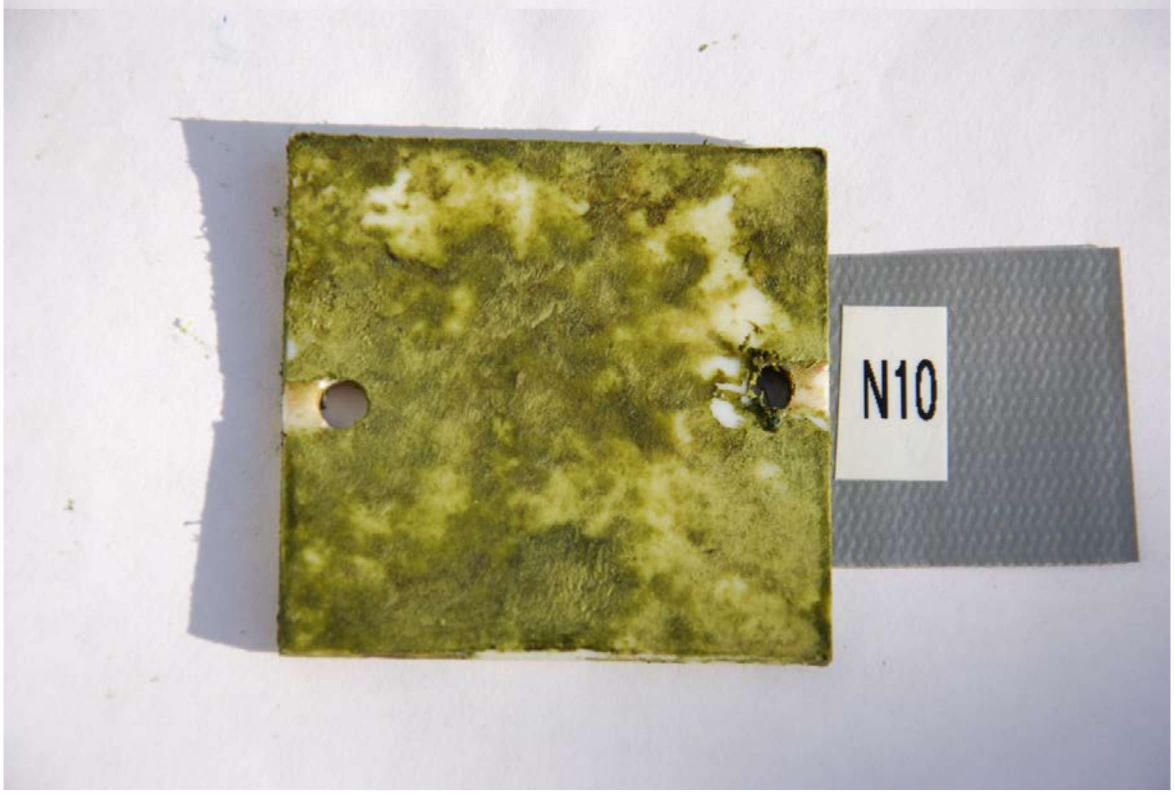

N5

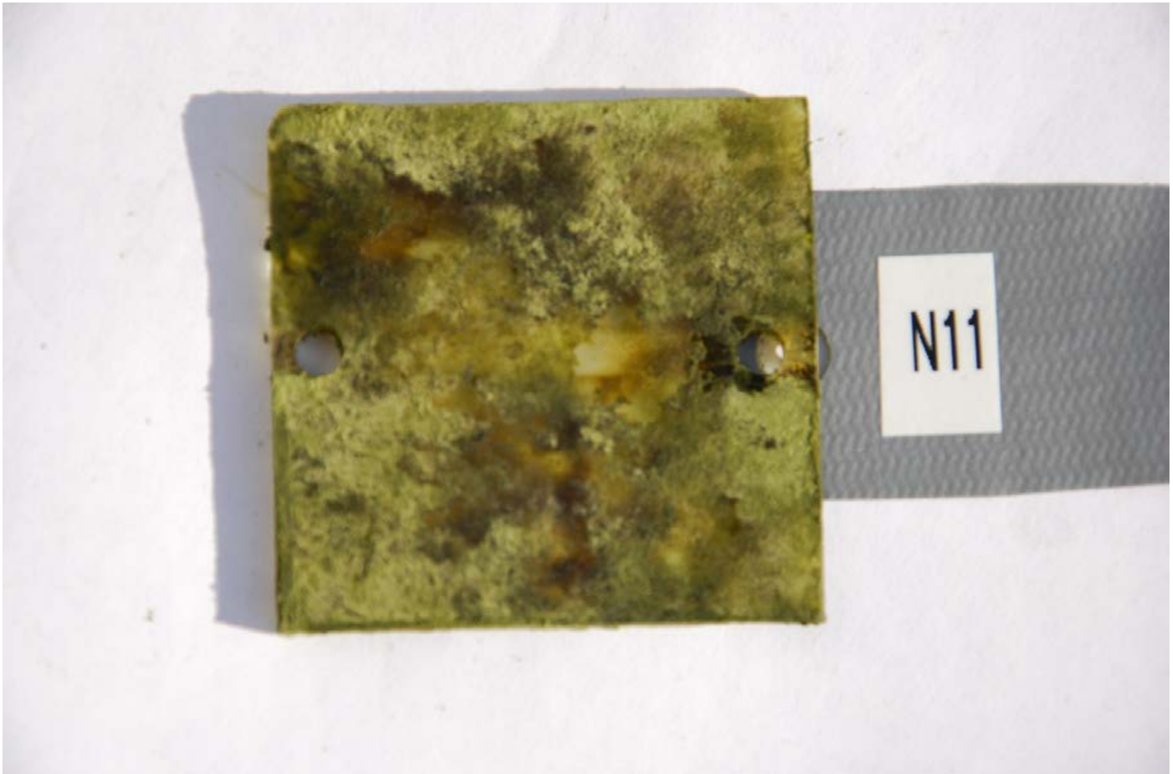

N6

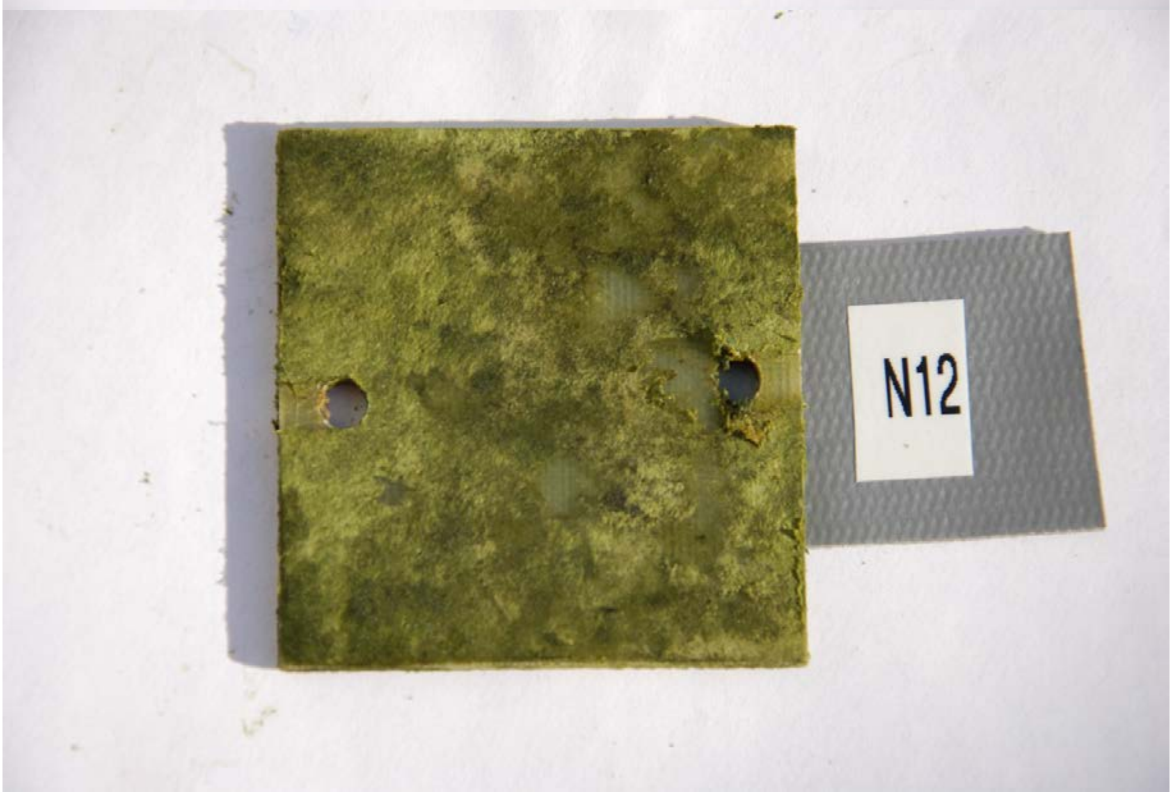

N7


N8


N9

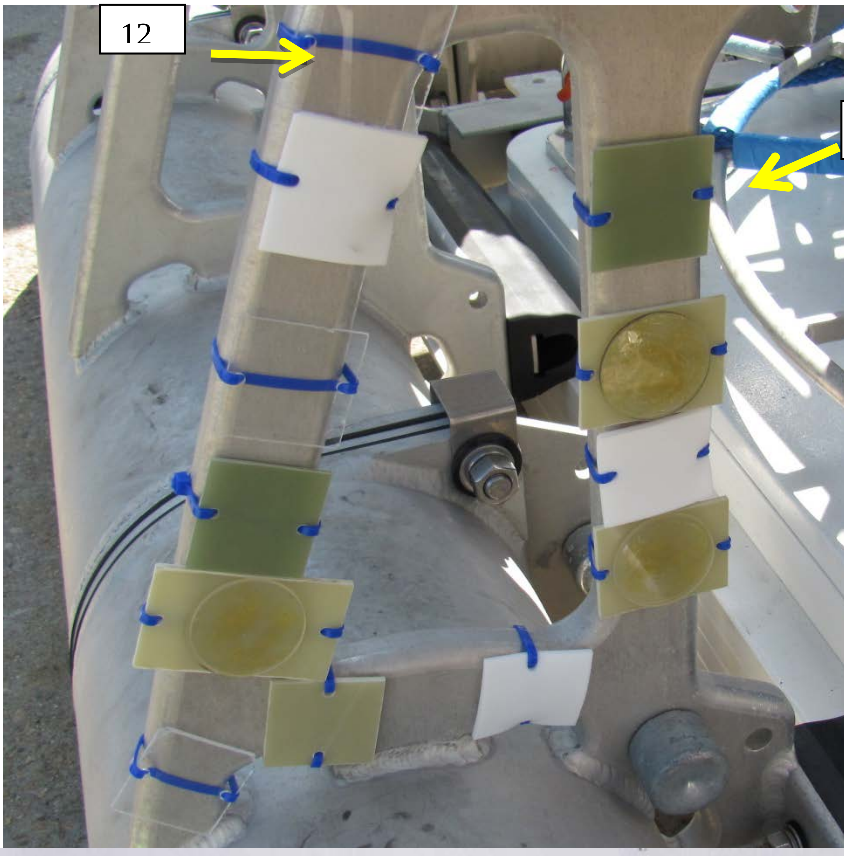

N10

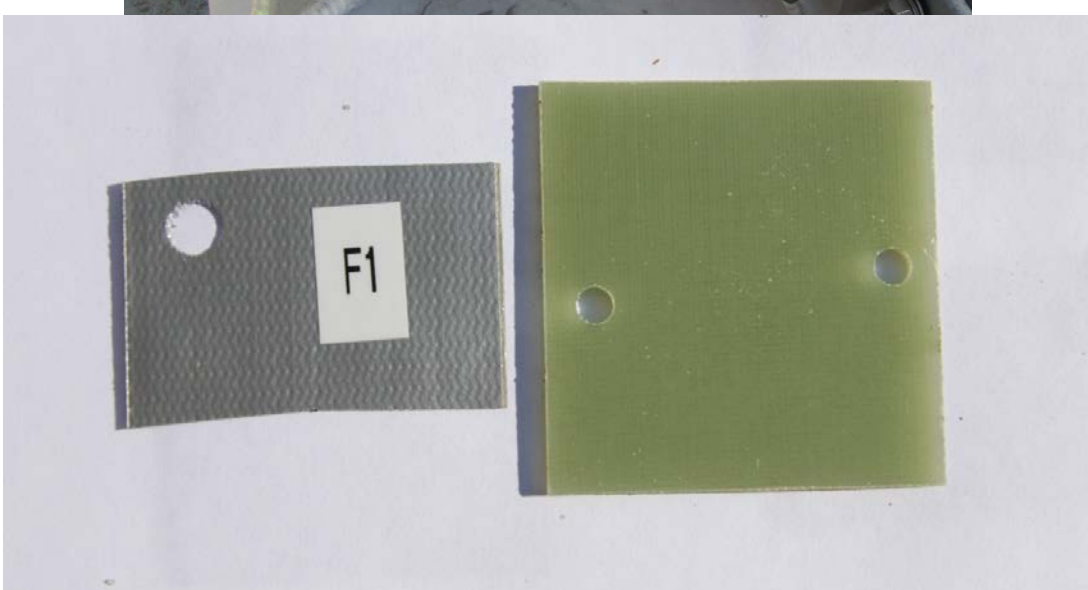

N11

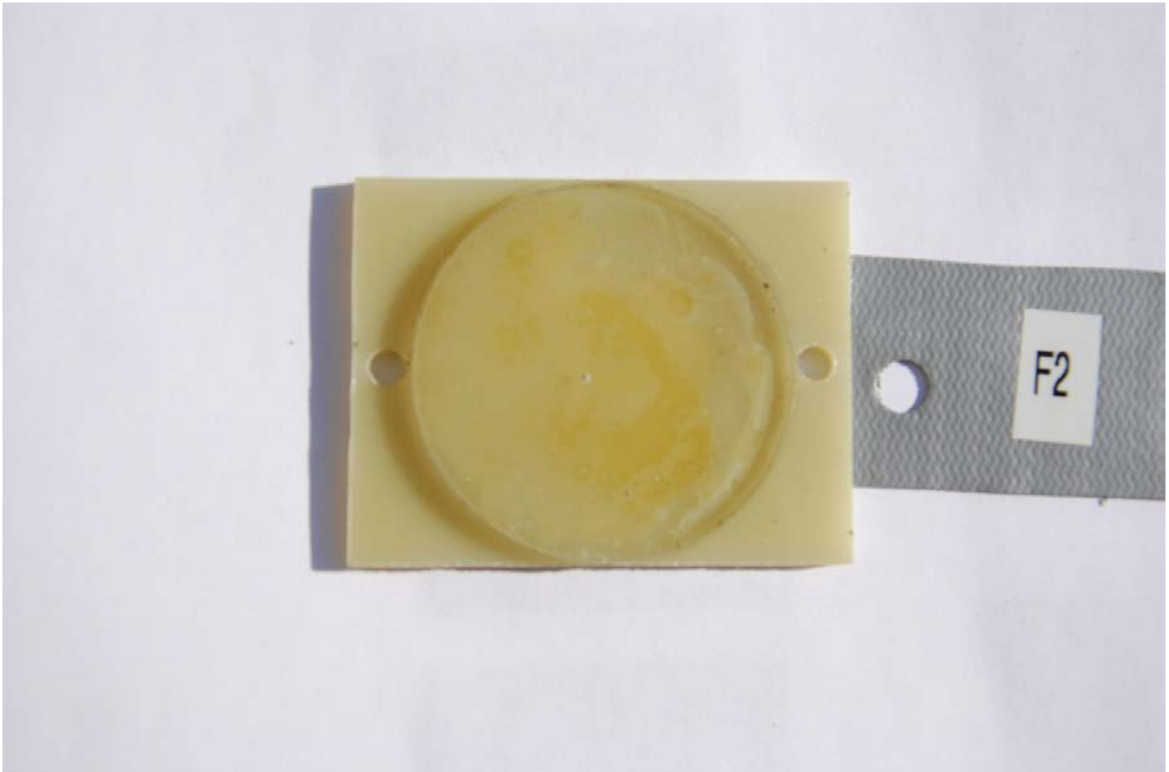

N12

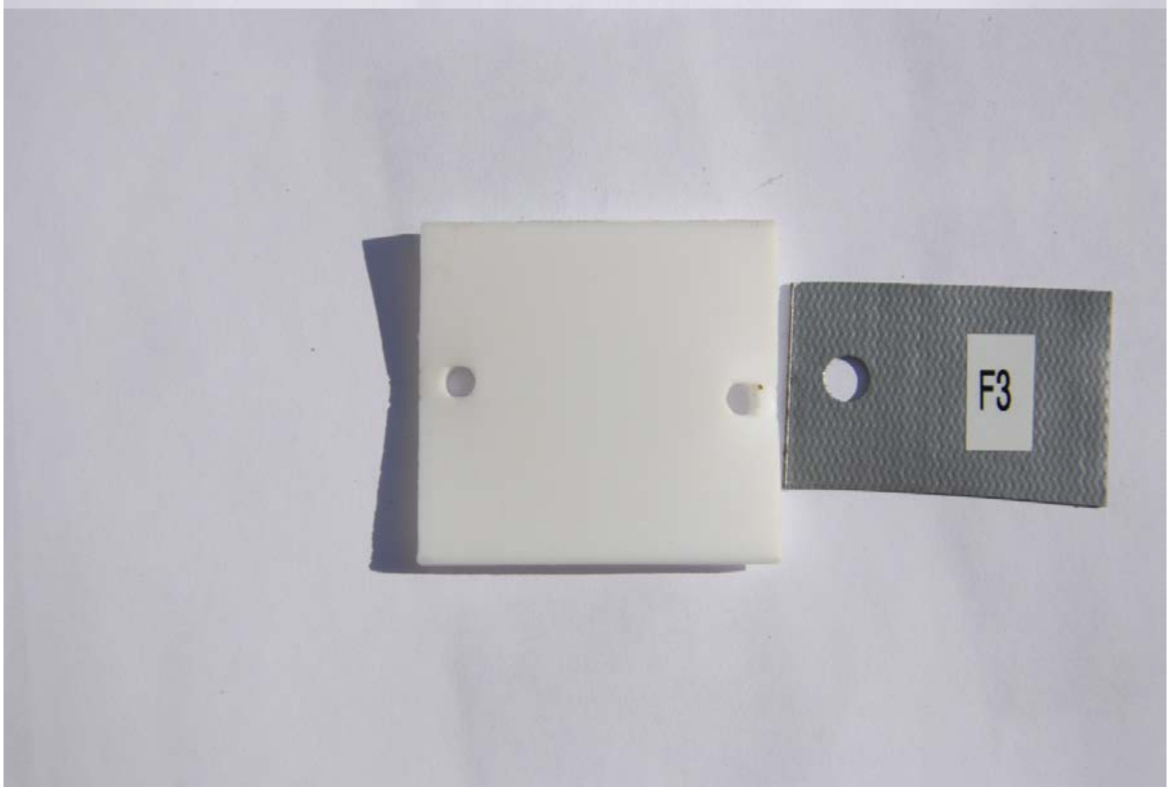
**Appendix 7: Biofouling Slides - BARF**

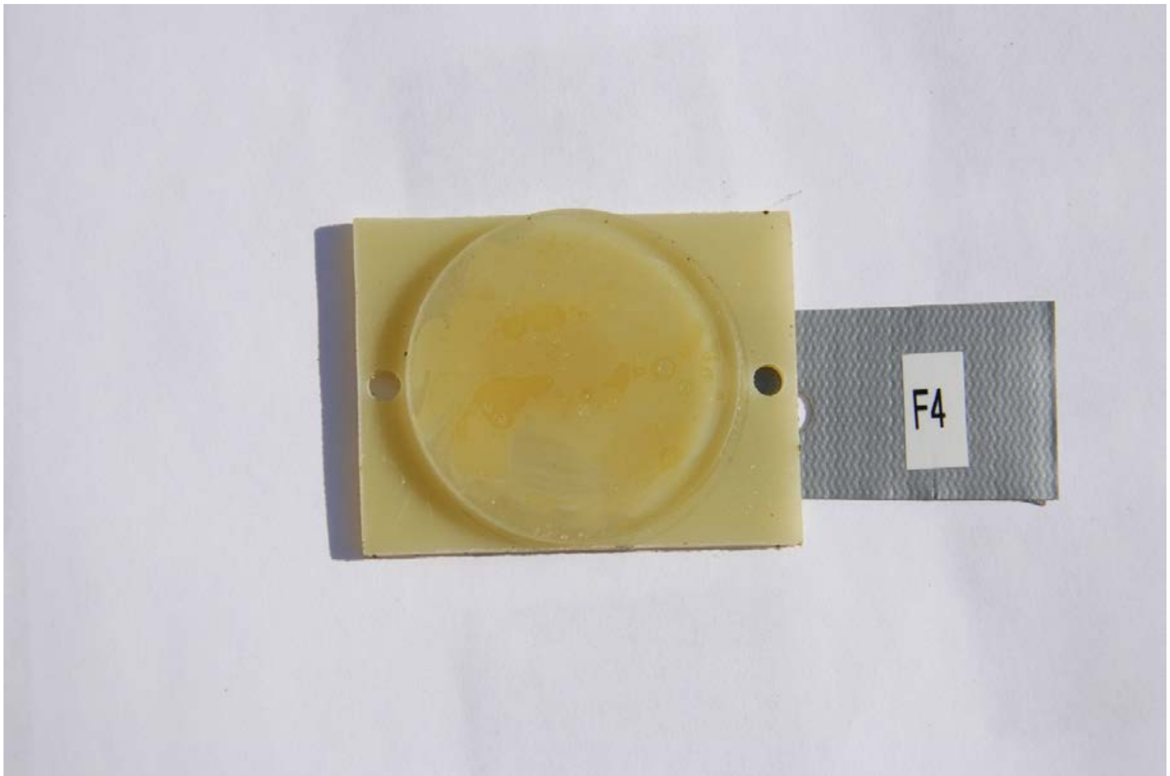
Near Surface Frame NSIF Slide numbered N 1-12 from the upper right clockwise:

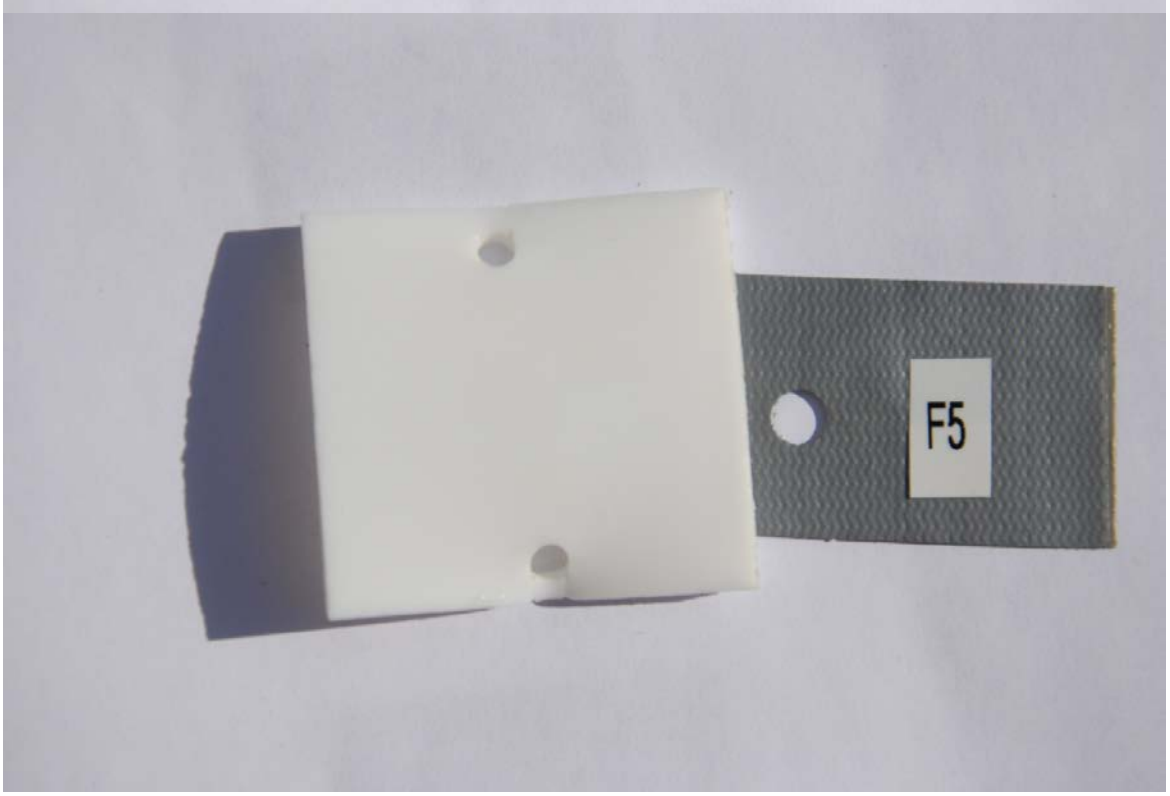


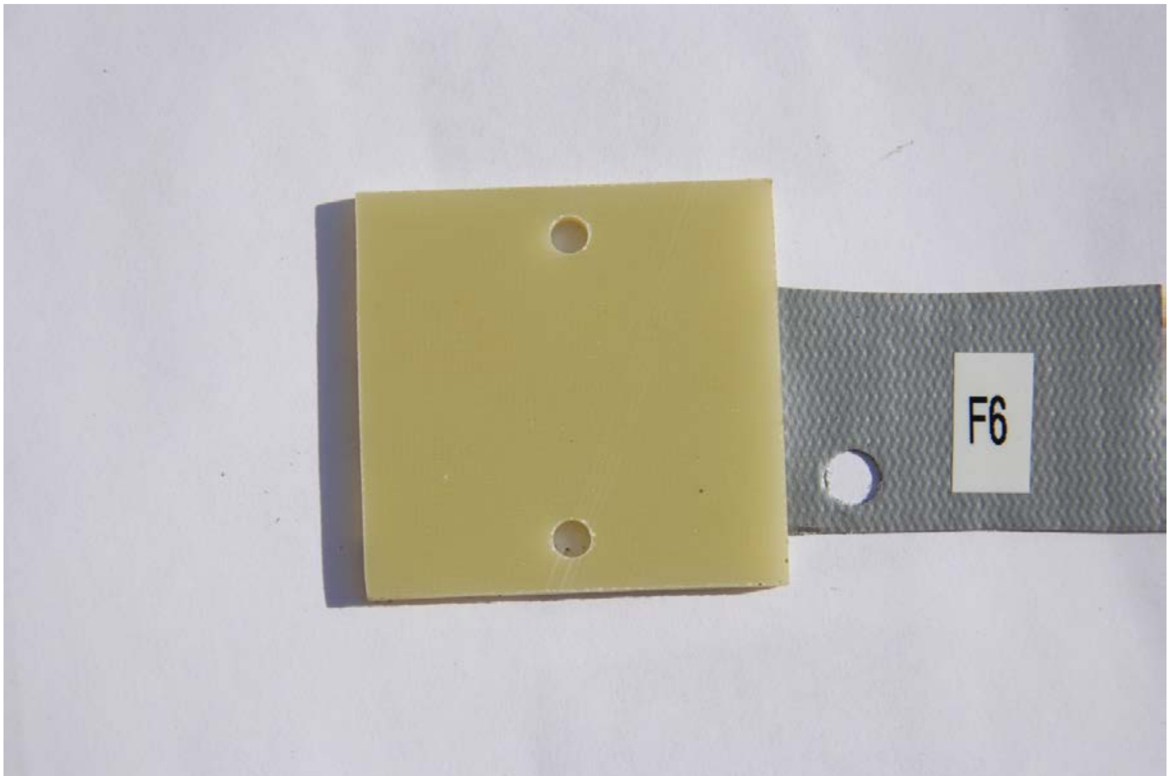



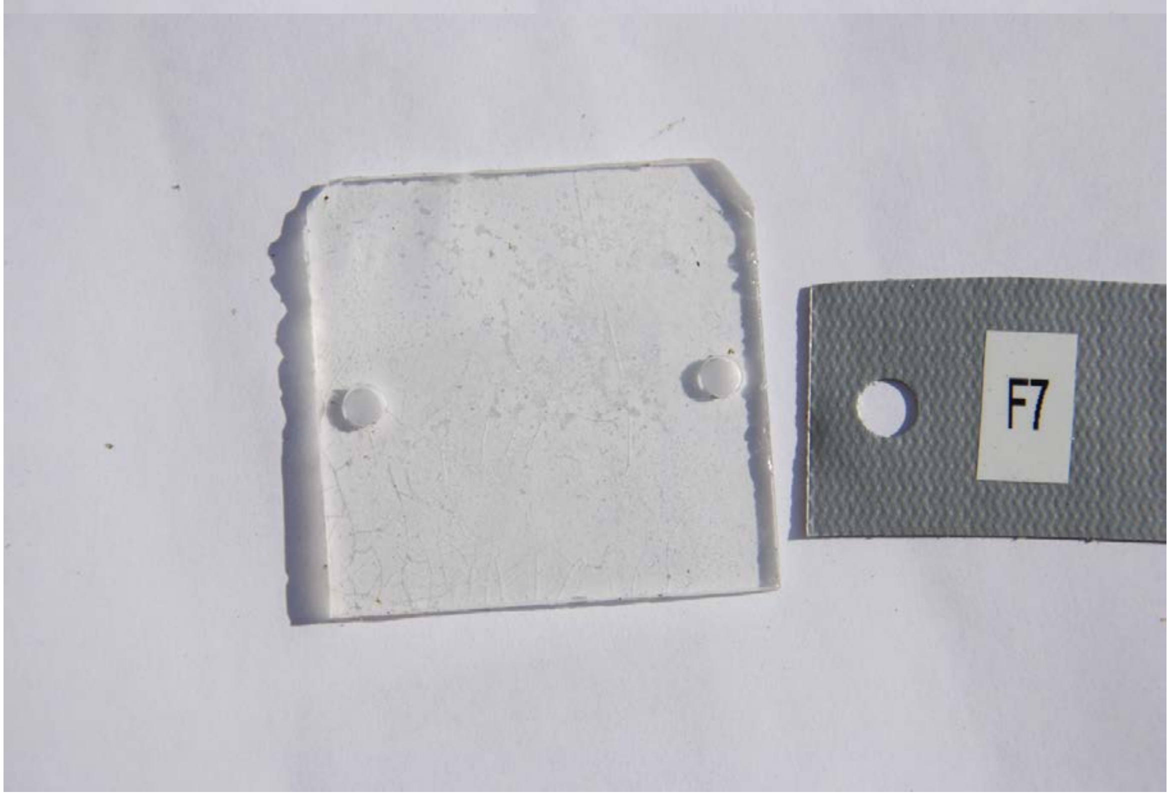

F2

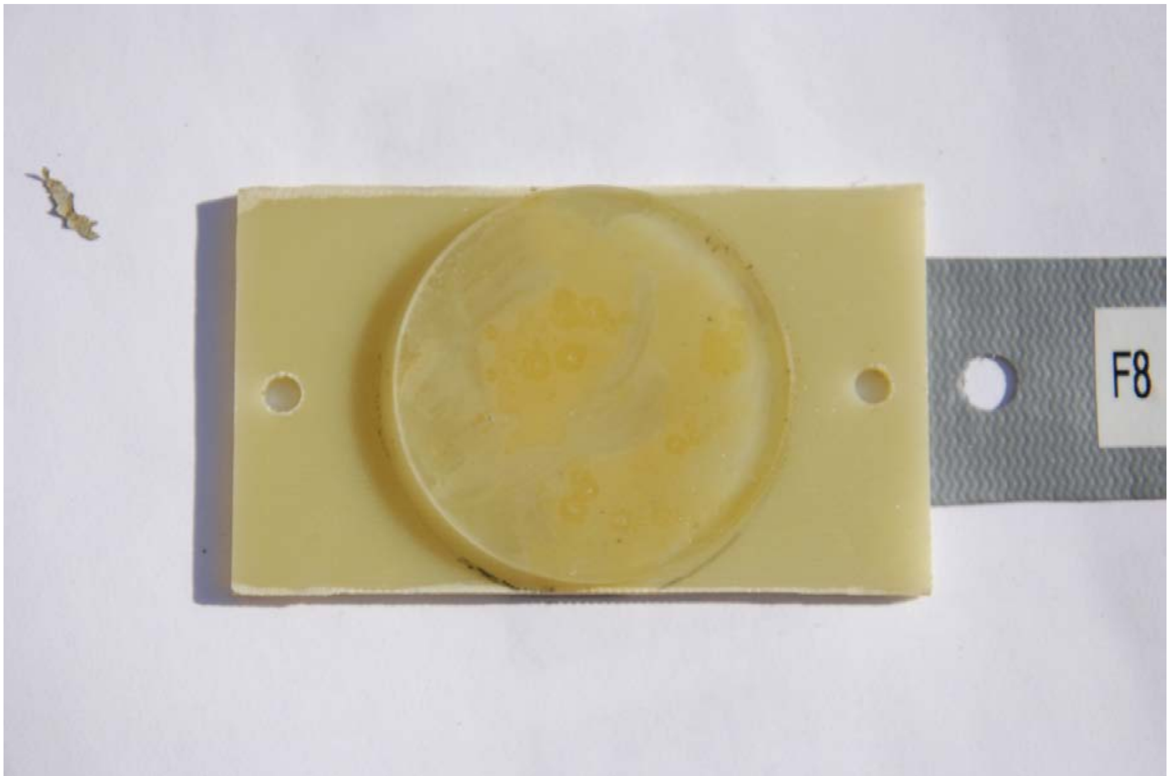

F3

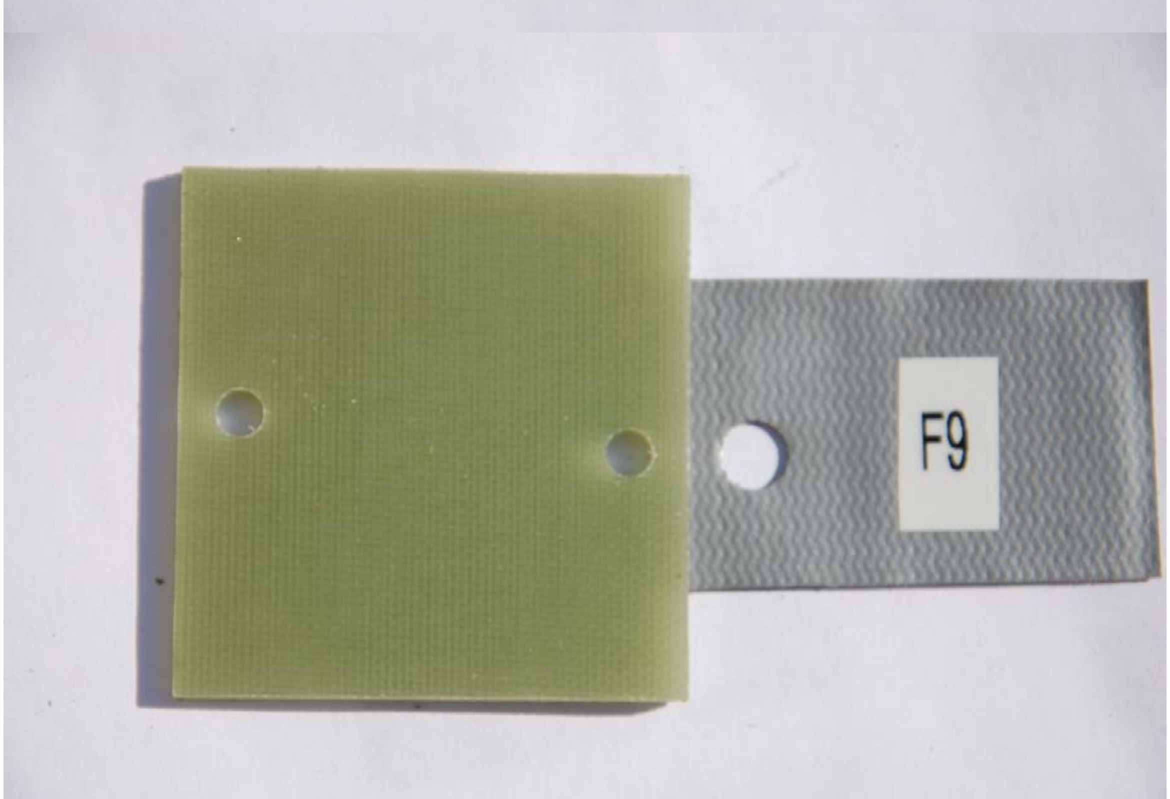

F4

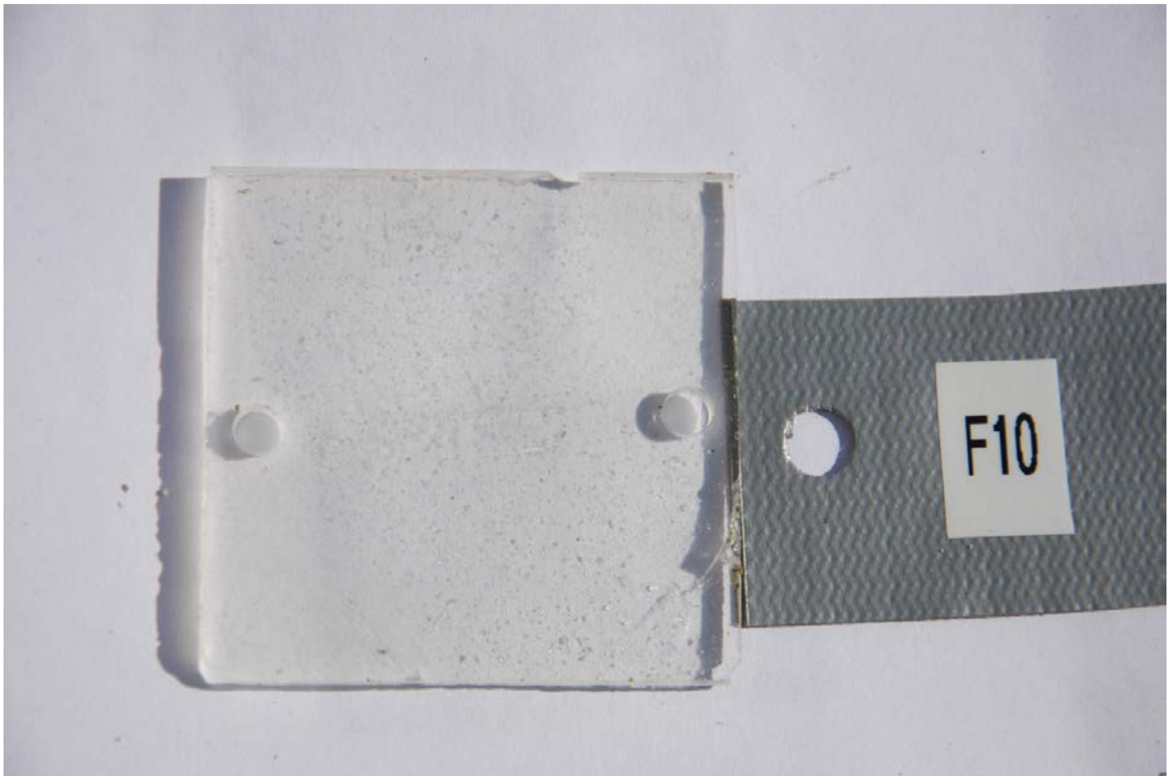

F5

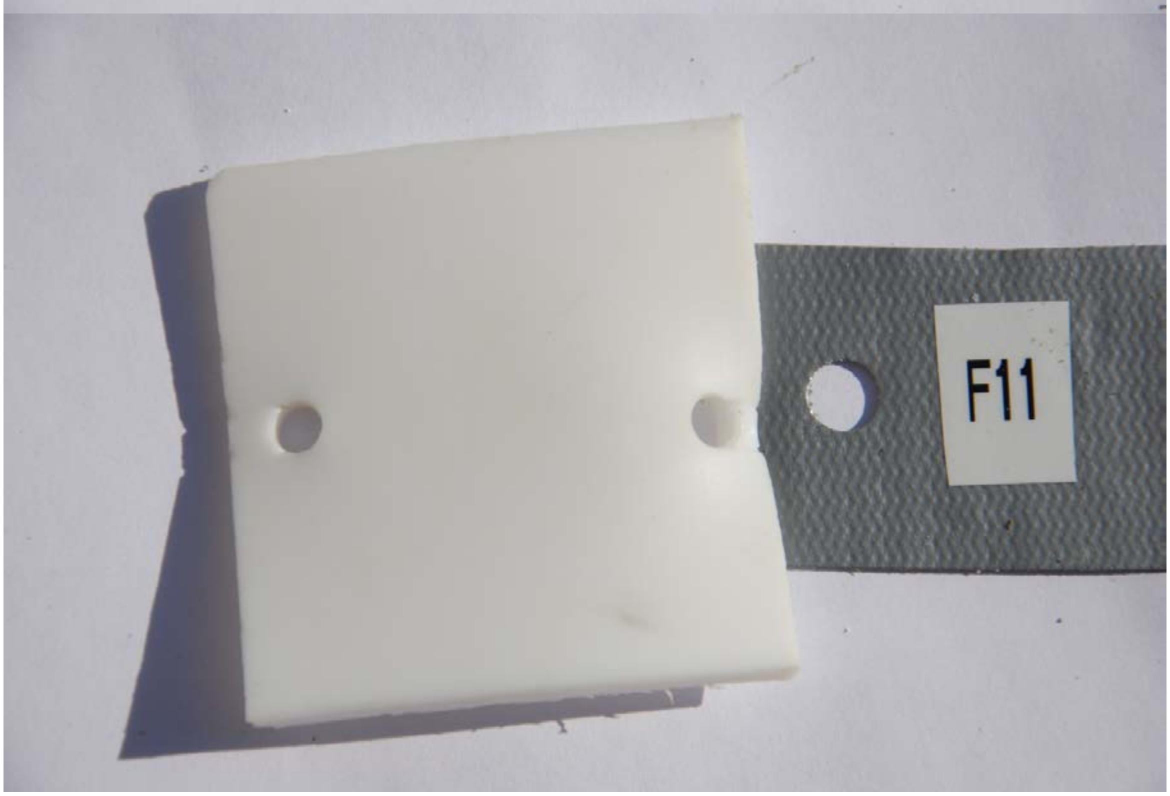

F6

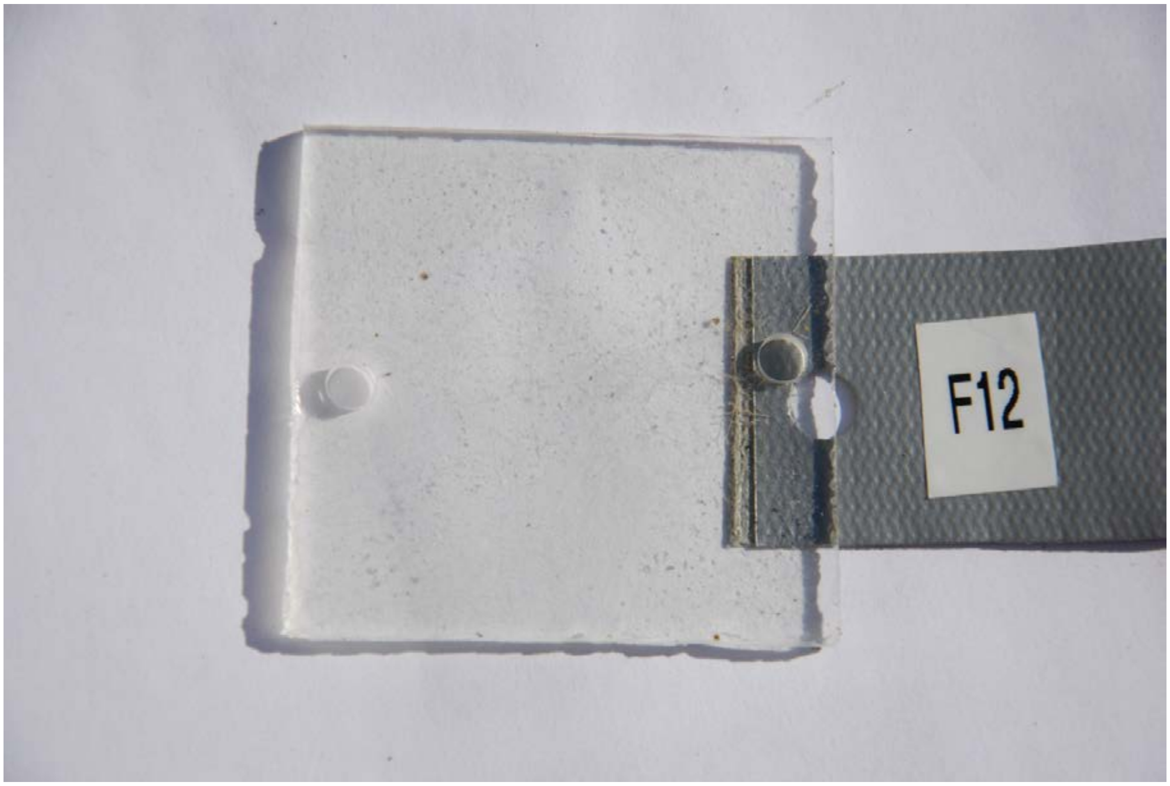

F7


F8


F9


F10


F11


F12

**Appendix 8: Bridge Log**

Page No. 1

Knorr Voyage No. 206

| Date 2012 | GMT +4 | Local Time | Fix | System I.D. | Quality of Observation | Latitute | Longitude |
|---|---|---|---|---|---|---|---|
| 4/10 | | 1430 | | | | 41-16.96 | 70-52.90 |
| | | 1600 | | | | 41-01.81 | 70-53.22 |
| | | 1800 | | | | 4041.34 | 7053.40 |
| | | 1900 | | | | 4030.17 | 7053.80 |
| | | 2000 | | | | 4018.84 | 7053.98 |
| | | 2100 | | | | 4007.59 | 7053.78 |
| | | 2200 | | | | 4006.35 | 7053.16 |
| | | 2300 | | | | 4006.15 | 7052.89 |
| 4/11 | | 0000 | | | TRIP 103 | 40-05.95 | 70-53.33 |
| | | 0200 | | | | 40-05.51 | 70-52.54 |
| | | 0400 | | | | 39-56.15 | 70-51.31 |
| | | 0825 | | | SEA CYCLE III | 39-26.86 | 70-48.98 |
| | | 1200 | | | | 39-28.47 | 70-47.44 |
| | | 1600 | | | | 39-28.72 | 70-49.27 |
| | | 1700 | | | CTD #1 | 39-28.31 | 70-49.30 |
| | | 1757 | | | ARGO #1 deployed | 3928.21 | 7049.72 |
| | | 1900 | | | | 3939.24 | 7049.65 |
| | | 2100 | | | | 4001.31 | 7048.54 |
| 4/12 | | 0000 | | | TRIP 113 | 40-05.35 | 70-41.60 |
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**Knorr Voyage No.** 206 **Page No.** 1 w

**Remarks:**

TUESDAY 10 APRIL 2012 T001Y

0900 SOE 0915 GEAR TEST. 1227 CAST LINE 1240 CLEAR 1+2.
1300 DEPARTURE.
1413 R/S 10 KTS FOR RIGHT WHALE ZONE
1728 F/A EXIT WHALE ZONE
2112 CML seabeam survey @ 6 kts

WEDNESDAY 11 APRIL 2012
0000 U/W 6K SURVEY W/ GEN 2+3 ONLINE.
0360 SURVEY COMPLETE U/W F/A FOR MOORING SITE.
0618 H/T @ MOORING "GHP" 0629 B/T↓
0825 SEA CYCLER ON SURFACE CMC APPROACH
0828 ALONGSIDE HOOKED. 0835 o/b 0907 RELEASE o/b
0950 standing by to recover lower part of Hybrid Profiler mooring
1030 Top float of lower half on sfc.
1052 glass floats on sfc
1100 top float hooked 1505 ALL MOORING GEAR o/b
1455 SMOKE IN STBD LAZ AFRAME HPU SECURED
1510 P. MARCZAK ON AIR ENTER LAZ TO INVESTIGATE
1516 P. MARCZAK OUT OF SPACE VENTILLATING & MONITORING
1530 REPOS FOR CTD 1606 H/T FOR CTD #1
1633 B/T ↑ 1702 GEN #2 TRIPPED 1704 GEN #3 ONLINE
1749 CTD 1 o/b
1800 u/w for 2nd survey start point 2024 c/c 008° PGC w/
CPPM → 1.5 mi
2142 CML "Central" survey

Page No. 2

Knorr Voyage No. 206

| Date 2012 | GMT +4 | Local Time | Fix | System I.D. | Quality of Observation | Latitute N | Longitude W |
|---|---|---|---|---|---|---|---|
| 4/12 | | 0100 | | | | 40-08.09 | 70-46.04 |
| | | 0300 | | | | 40-02.63 | 70-45.82 |
| | | 0400 | | | | 40-01.25 | 70-46.98 |
| | | 0708 | | | CTD #2 | 39-56.62 | 70-51.22 |
| | | 1200 | | | | 39-54.72 | 70-47.71 |
| | | 1600 | | | | 39-54.83 | 70-48.48 |
| | | 1800 | | | | 39 59.80 | 70 52.98 |
| | | 1900 | | | | 4005.58 | 7052.96 |
| | | 2100 | | | | 4017.31 | 7052.98 |
| | | 2300 | | | | 4017.65 | 7054.45 |
| 4/13 | | 0000 | | | TRIP 86 | 40-11.59 | 70-53.48 |
| | | 0307 | | | | 40-20.35 | 7057.15 |
| | | 0400 | | | | 40-11.31 | 70 57.15 |
| | | 1600 | | | | 39-57.91 | 70-45.75 |
| | | 1800 | | | | 4009.96 | 7045.74 |
| | | 1900 | | | | 4016.08 | 7045.75 |
| | | 2100 | | | | 4018.26 | 7046.09 |
| | | 2200 | | | | 4012.50 | 7046.16 |
| | | 2300 | | | | 4006.42 | 7046.22 |
| 4/14 | | 0000 | | | [illegible] | 40-[illegible] | |
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Knorr Voyage No. 206 Page No. 2

**Remarks:**

THURSDAY 12 APRIL 2012 ZD+4
0000 u/w 6k GEN 2+3 ONLINE. SURVEYING.
0330 SURVEY COMPLETE u/w F/A FOR "CPPM". 0430 H/T @ MOORING SITE. 0530 CMC SURVEY of MOORINGS.
0648 H/T FOR CTD 0655 CMC CTD 2 0720 CTD o/b
0730 F/A FOR "CPPM" MOORING 0748 H/T 0752 BT ↓
0810 CPPM RELEASED, 0820 FLOATS ON SURFACE, CMC APPROACH
0920 CMC HAULING BACK TOP FLOAT.
1108 hard hat floats on board
1118 Line pack on board
1334 ⚓ o/b CPPM MOORING
1515 B/T ↑
1603 GEN #1 ON GEN #2 OFF

1710 CMC SB SURVEY N BOUND
2010 c/c TMG 180° PGC

FRIDAY 13 APRIL 2012 ZD+4
0000 u/w SURVEYING. 6k GEN 1+3 ONLINE. 180 T.
0636 H/T @ CPSM 0643 B/T ↓, 0755 CPSM RELEASED
0825 CMC APPR. 0830 HOOKED. CMC DRAGGING BACK TO ANCHOR SITE. 0930 TOP FLOAT o/b.
1115 BARF @ SFC 1257 BARF o/b
1435 ⚓ 1448 B/T ↑ u/w FOR SURVEY
2024 c/c TMG 180° T

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Knorr Voyage No. 206

| Date 2012 | GMT +4 | Local Time | Fix | System I.D. | Quality of Observation | Latitute | Longitude |
|---|---|---|---|---|---|---|---|
| 4/14 | | 0000 | | | TRIP 403.11 | 40-00.11 | 70-46.32 |
| | | 0100 | | | | 39-55.50 | 70-47.01 |
| | | 0200 | | | | 40-02.02 | 70-46.81 |
| | | 1000 | | | | 39 55.36 | 70 47.62 |
| | | 1005 | | | X13T | 39 55.10 | 70 47.63 |
| | | 1200 | | | | 40-06.85 | 70-47.70 |
| | | 1300 | | | | 40-14.36 | 70-47.34 |
| | | 1400 | | | | 40-21.04 | 70-46.94 |
| | | 1500 | | | | 40.18.99 | 70-47.40 |
| | | 1600 | | | | 40-12.84 | 70-47.78 |
| | | 1800 | | | | 40 00.53 | 70 48.55 |
| | | 1900 | | | | 39 55.11 | 70 49.55 |
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**Knorr Voyage No.** 206

| Date 2012 | GMT +4 | Local Time | Fix | System I.D. | Quality of Observation | Latitute | Longitude |
|---|---|---|---|---|---|---|---|
| 4/14 | | 0000 | | | TRIP 103 | 40-00.11 | 70-46.32 |
| | | 0100 | | | | 39-55.50 | 70-47.01 |
| | | 0200 | | | | 40-02.02 | 70-46.81 |
| | | 1000 | | | | 39 55.36 | 70 47.62 |
| | | 1005 | | | X13T | 39 55.10 | 70 47.63 |
| | | 1200 | | | | 40-06.85 | 70-47.70 |
| | | 1300 | | | | 40-14.36 | 70-47.34 |
| | | 1400 | | | | 40-21.04 | 70-46.94 |
| | | 1500 | | | | 40.18.99 | 70-47.40 |
| | | 1600 | | | | 40-12.84 | 70-47.78 |
| | | 1800 | | | | 40 00.53 | 70 48.55 |
| | | 1900 | | | | 39 55.11 | 70 49.55 |
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Remarks:

SATURDAY 14 APRIL 2012

0000 U/W 6K SURVEYING GEN 1+3 ONLINE.

50272-101

| REPORT DOCUMENTATION PAGE | 1. REPORT NO. WHOI-2012-07 | 2. | 3. Recipient's Accession No. |
|---|---|---|---|

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|---|---|
| 4. Title and Subtitle<br>At Sea Test 2 Recovery Cruise<br>Cruise 206 On Board R/V Knorr April 10 - 15, 2012 Woods Hole - Woods Hole, MA | 5. Report Date<br>June 2012<br>6. |
| 7. Author(s) Robert A. Weller, John Lund, Jeff O'Brien, John Kemp, Ken Kostel, Walt Waldorf, Chris Holm, Craig Risien, Michael Matthewson, John Trowbridge | 8. Performing Organization Rept. No. |
| 9. Performing Organization Name and Address<br>Woods Hole Oceanographic Institution<br>Woods Hole, Massachusetts 02543 | 10. Project/Task/Work Unit No.<br>11. Contract(C) or Grant(G) No.<br>(C)<br>(G) |
| 12. Sponsoring Organization Name and Address<br>National Science Foundation | 13. Type of Report & Period Covered<br>Technical Report<br>14. |

15. Supplementary Notes

This report should be cited as: Woods Hole Oceanographic Institution Tech Report, WHOI-2012-07.

16. Abstract (Limit: 200 words)

The R/V Knorr, on Cruise 206, carried out the recovery of three moorings for the Coastal and Global Scale Nodes (CGSN) Implementing Organization of the NSF Ocean Observatories Initiative. These three moorings are prototypes of the moorings to be used by CGSN at the Pioneer, Endurance, and Global Arrays. Knorr departed from Woods Hole, Massachusetts on April 10, 2012 and steamed south to the location of the mooring deployments on the shelf break. Over five days, April 10-15, Knorr surveyed the bottom at the planned mooring sites, recovered the moorings, and carried out preliminary investigations of mechanical and electrical functionality on the recovered moorings and mooring hardware, including observations of biofouling and corrosion. Knorr returned to Woods Hole on April 15, 2012.

17. Document Analysis a. Descriptors

moorings
real-time system
OOI CGSN AST2

b. Identifiers/Open-Ended Terms

c. COSATI Field/Group

| 18. Availability Statement | 19. Security Class (This Report) | 21. No. of Pages |
|---|---|---|
| Approved for public release; distribution unlimited. | UNCLASSIFIED | 94 |
| | 20. Security Class (This Page) | 22. Price |

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